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APPLICABILITY OF
NATIONAL DATA BUOY SYSTEMS TO
REFINED NATIONAL REQUIREMENTS FOR
MARINE METEOROLOGICAL AND OCEANOGRAPHIC DATA

Volume I

by

LeRoy H. Clem
Project Scientist

and

Gaylord M. Northrop

October 1968

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TRC Report 7493-332a
Prepared for the U.S. Coast Guard
Under Contract No. DOT-CG-82504-A

E. J. Aubert
G. M. Northrop
Principal Investigators

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National Data Buoy Systems Designated Project Office under
Contract DOD-CG-82504-A.

Views or conclusions contained in this study report should not
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Government.

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250 Constitution Plaza Hartford, Connecticut 06103**

FOREWORD

Contract Number DOT-CG-82504-A between the U. S. Coast Guard and The Travelers Research Center, Inc. (TRC) consists of five parallel activities. The five final reports stemming from these activities are entitled:

- (1) Applicability of National Data Buoy Systems to Refined National Requirements for Marine Meteorological and Oceanographic Data (two volumes).
- (2) Characteristics of National Data Buoy Systems: Their Impact on Data Use and Measurement of Natural Phenomena
- (3) Cost Effectiveness Sensitivity of National Data Buoy Systems: An Essay
- (4) Computer Programs for National Data Buoy Systems Simulation and Cost Models
- (5) An Analysis of Cruise Strategies and Costs for Deployment of National Data Buoy Systems

Each of these five reports is complete in itself, but it must be recognized that in all instances the other four activities both influenced and contributed to the results presented in each individual report.

The present USCG/TRC contract is an outgrowth of a study of the feasibility of national data buoy systems performed by TRC and Alpine Geophysical Associates for the USCG during 1967. Need was evident for investigation, research, and analysis in greater depth in several areas to support the concept formulation and deployment planning efforts of the newly-formed U. S. Coast Guard National Data Buoy System Designated Project Office (NDBS DPO). This report and the other four cited above satisfy some of those needs.

All five TRC reports have benefited from the close cooperation and guidance afforded by the USCG NDBS DPO. Contributions have been made by Capt. J. Hodgman (Project Manager), Cmdr. V. Rinehart, J. Wesler, E. Parker, and P. Merrill, and Lt. Cmdr. W. Merlin (Contract Monitor).

The authors wish to acknowledge the technical support and contributions provided by Paul R. MacDonald and Paul V. Luty of the TRC Technical Staff.

SUMMARY, VOLUME I

This report documents the 1968 refinement of national requirements for marine meteorological and oceanographic data -- initially compiled during the 1967 Study of the Feasibility of National Data Buoy Systems (NDBS)--and shows the applicability of certain postulated NDBS sensing characteristics to a subset of the refined data requirements. National data requirements to support operational and research activities are presented; they include physical, biological, chemical, geological, and radiological parameters which are to be measured throughout the world's oceans from the ocean bottom to 100,000 feet in the atmosphere. The data requirements are projected from the present to as far as 15 years into the future. The applicability of possible future National Data Buoy Systems (NDBS) to 1968 refined national data requirements is illustrated by the use, for reference purposes only, of the potential sensing capabilities (parameters and measurement characteristics) of a hypothetical data buoy "system".

The comprehensiveness and accuracy of the 1967 statements of data requirements were constrained by a lack of requirements collection precedence and by the usual difficulties encountered in collecting environmental data requirements from a wide variety of government agencies. The 1967 data requirements were collected without benefit of complete standardization or reference to the sensing characteristics shown to be economically and technically feasible in the 1967 TRC study. The U. S. Coast Guard was assigned development responsibility for the NDBS in November 1967. The USCG National Data Buoy Systems Designated Project Office (NDBS DPO) established a data requirements refinement effort as one activity of Contract DOT-CG-82504-A, to obtain more up-to-date, accurate, complete, and clearly-defined statements of data requirements, suitable for the initial phases of system development planning. Standardization of terms and units was sought and refinement of data requirements in the Deep Ocean (DO)* and Coastal North American (CNA)** regions were solicited from the U. S. Government agencies that had provided data requirements for the 1967 feasibility study. Throughout this work, operational data requirements have been emphasized somewhat more than research requirements because of their more stable, long-term nature and because of the potential benefits that might be realized by

*Beyond 400 n mi of North American Coast.

**Within 400 n mi of North American Coast.

implementation of an NDBS capable of satisfying operational requirements at the earliest possible time.

The 1968 data requirements refinement and the analysis of the applicability of hypothetical NDBS sensing characteristics were conducted in several phases. First, from the results of review of 1) the 1967 statements of data requirements, 2) the 1967 projected estimates of 5-year buoy state-of-the-art (SOA), and 3) the results of the 1967 feasibility study, a hypothetical data-buoy "system" was conceptualized for reference purposes (with a few important exceptions, this "strawman system" was comparable to those postulated in the 1967 feasibility study). Second, an assessment was made of how well each set of the 1967 data requirements would be met by this hypothetical "system." Third, the results of this assessment, together with questions that arose during the analysis and assessment, were forwarded to the pertinent agencies for refinement action. Fourth, responses (including answers to specific questions submitted to the agencies) were analyzed, assessed, and translated into tentative NDBS sensing characteristics needed to meet data requirements in various marine regions. Finally, the refined data requirements were interpreted in terms of tentative observation sites in hypothetical DO and CNA "system" networks in 13 geographical regions called Modular Deployment Zones (MDZ).

After receiving the TRC review and assessment of their 1967 statements of data requirements, the agencies made refinements to their data requirements in light of the potential sensing characteristics of the hypothetical, technologically feasible NDBS. When the refined data requirements were returned to TRC, they were again assessed and tallied in the following manner: Total operational data requirements for observations of data at sites were sorted by agency-mission-operations (AMO), by agency, by DO and CNA regions, and by 13 geographical regions called Modular Deployment Zones (MDZ). In each sort, where applicable, the distribution of requirements to collect data at observation sites was established and the redundancy or common use of observation sites, where possible, was analyzed to reduce the number of required sites. For example, various operations within an agency (or among agencies) might have requirements for data (the same or different parameters) from the same type of observational network in a given geographical area. The total number of requirements for observations would thus be larger than the number of sites required to meet them.

The required observation sites were then related to those that conformed to the network sites of the reference "system." Required observation sites were then classified as "system" or non-"system." A similar analysis of the numerical distribution of specific parameter requirements was performed for "system" and non-"system" sites within each MDZ. For each of the 13 MDZs, the total number of operational requirements for data collection at each "system" site and corresponding total requirements for specific parameters have been established, thus demonstrating the degree of utility for each "system" observation site. The complete analysis also covers non-"system" sites in the same manner and illustrates the low operational utility of these sites. A similar, but less extensive, analysis was made of research requirements that were either met or partially met by the hypothetical reference "system".

Finally, all operational requirements and selected research requirements (those research requirements for which the hypothetical "system" had considerable applicability) were combined into national data requirements and assessed for numerical distribution of requirements for observations at sites that could be assumed to be those of the hypothetical reference "system." This indicates the degree of potential utility of the hypothetical reference "system" for satisfying combined national requirements.

In total, there are 1,893 DO and 1,353 CNA requirements for data collection at sites for combined national interests that could be met by hypothetical "system" observation sites. When the potential reduction of observation sites made possible through the common use of a site is taken into account, the net number of required hypothetical "system" observation sites is 261 for the DO region and 279 for the CNA region. Thus, a 7:1 average ratio of combined requirements-for-data-collection-at-observation-sites to "system" observation sites is achieved in the Deep Ocean MDZs, and approximately a 5:1 average ratio of requirements to "system" sites is established in the Coastal North American MDZs.

Of course, these findings are based upon the assumption that the 1968 statements of refined data requirements are the best presently available and collectively represent the national interests. About mid-1968, estimates of the relative values of parameters and observing layers were solicited from four agencies with operational missions. The agency responses indicated that additional information, related to data requirements

and useful for NDBS development planning, can be obtained. This initial effort has made clear that further work of this kind should be undertaken in the future.

The ultimate sensing characteristics of various National Data Buoy Systems have not yet been finalized. The statements of data requirements presented in this report provide a base for assessment of hypothetical, technically feasible sensing characteristics,* thus adding another dimension to preliminary system development planning. Among other important features of evolving NDBS system development planning that will doubtless influence the NDBS sensing characteristics ultimately implemented are cost-effectiveness studies, trade-offs of potential development vs off-the-shelf equipment acquisition, relative values of data from contiguous geographical regions, research, economic, social, and military benefits, and national and international relative worth of the NDBS (or, the data collected by the NDBS). Within this context, the conclusions of this study are as follows:

- The continuing evolutionary nature of requirements for marine environmental data must be recognized. It is the result of numerous factors. Annual review and refinement of requirements will probably be necessary throughout the foreseeable future.
- Agency representatives have demonstrated a willingness and ability to estimate the relative importance of parameters and observing layers as part of the continued refinement of data requirements. A more intensive program to develop and exploit quantified ratings of this type should be undertaken.
- Horizontal spacings for Deep Ocean buoy networks of 600 n mi and Coastal North American network spacings of 100 to 150 n mi appear to be generally acceptable for an initial NDBS and appear to serve the stated needs of many activities. A total of 261 DO and 279 CNA data buoys would be needed to satisfy these horizontal spacing requirements in the ocean areas.
- Twenty parameters in the following table & their measurement characteristics (see Appendix IV) are suggested as representative of the basic sensing characteristics of a future DO or CNA NDBS. They are the result of the assessment of refined 1968 data requirements and appear to be generally

*Technically feasible sensing characteristics are defined as those estimated to be achievable within 5 years by conventional development effort.

acceptable to the involved U.S. Government agencies at this time. Inclusion of additional parameters of high common need or importance in specific geographic regions appears indicated. Development of new sensing capabilities for some of the additional parameters (e.g., upper air parameters) appears worthy of further consideration.

TABLE OF BASIC PARAMETERS SUGGESTED TO BE REPRESENTATIVE OF POSSIBLE FUTURE NDBS SENSING CHARACTERISTICS

<u>Meteorological</u>	
● Air temperature	● Insolation
● Atmospheric electricity	● Precipitation rate
● Atmospheric pressure	● Wind direction
● Dew point	● Wind speed
<u>Oceanographic</u>	
● Ambient light	● Water pressure (depth)
● Ambient noise	● Water temperature
● Current direction	● Wave and swell:
● Current speed	● Direction
● Salinity	● Height
● Sound speed	● Period
● Transparency	

In preparing this report, it has been the intent of the authors to document as clearly as possible the steps involved in the collection and assessment of data requirements, and the analysis leading to further delineation of the basic sensing characteristics of future National Data Buoy Systems. There is much yet to be learned about the marine environment; data requirements will likely change in the future in an evolutionary fashion. The NDBS will be but one data collection system operating ultimately within the context of a total national marine environmental data collection system. Thus, this report may be of use or guidance, not only in support of NDBS development planning, but also to agencies having requirements now or in the future for data from the marine environment and agencies having present or future responsibilities for developing and/or operating the other data collection systems that will comprise the rest of the national marine environmental data collection system.

Therefore, this report has, to the extent possible, been structured to keep this larger task in view, while at the same time concentrating on details most relevant to NDBS development.

Many of the results and conclusions discussed in this report are based on interpretations by the authors of data requirements collected from U. S. Government Agencies. Often, interpretations were made in areas that are recognized to be controversial. The cooperating agencies are encouraged to "set the record straight" on any point where these interpretations may not have hit the mark. Ultimately, it is hoped that through interactive efforts, such as described in this report, procedures that are both useful and acceptable to all concerned will evolve and the major task of developing an effective national marine environmental data collection system will be accomplished.

SUMMARY, VOLUME II

Volume II of the report, The Applicability of National Data Buoy Systems to Refined National Requirements for Marine Meteorological and Oceanographic Data, contains the five Appendixes for Volume I, the basic report, as listed in the Table of Contents.

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1.0 INTRODUCTION

This report documents the 1968 refinement of the national requirements for marine meteorological and oceanographic data and shows the applicability of certain postulated National Data Buoy Systems (NDBS) sensing characteristics to a subset of the refined data requirements. The data requirements were first established early in 1967 as the first phase of the Study of the Feasibility of National Data Buoy Systems. The 1968 refined national data requirements of operational and research users are included in this report. These requirements span the world's oceans and, in the vertical, extend from the ocean bottom to 100,000 feet in the atmosphere. The data requirements cover the time period from the present to as far into the future as can be projected: up to 15 years. The required data include physical, biological, chemical, geological and radiological parameters.

The national data requirements that were refined during this contract (DOT-CG-82504-A) were originally compiled under U. S. Coast Guard (USCG) Contract TCG-16790-A with the details of that work covered in The Travelers Research Center's (TRC) Feasibility Study Final Report - Volume I, Part 1 [1]. The overall objectives of that 1967 study were to identify from the compiled national requirements for marine meteorological and oceanographic data the subset of requirements that could, on a cost-effectiveness basis, best be acquired by buoy systems, and to develop a plan for meeting that subset of data requirements. The data requirements that were collected in 1967 to meet part of the first objective were considered representative of most types of national marine activities and, although not exhaustive, covered all the data requirements - not just that subset best met by buoys. However, it should be noted that this initial compilation of marine data requirements was really the first detailed statement of such national requirements ever formally made and represents the information as it was understood at that time by the various users interviewed. It did not represent the results of objective analyses of the users' activities to determine the sensitivity of their operations to environmental parameters. It was apparent in view of these restrictions and the limited experience of the users with adequate marine data, that these early 1967 statements of data requirements could be improved by updating, expansion, and refinement. Although originally adequate for a feasibility study, the data

requirements collected in early 1967 had a number of deficiencies including omissions, insufficient information, inconsistencies, errors and, in some cases, obsolescence.

In November 1967, the U. S. Coast Guard was assigned lead-agency responsibility by the National Council for Marine Resources and Engineering Development for the design and development, up to implementation, of a national data-buoy systems capability. The deficiencies in the 1967 statements of data requirements, and the fact that they were collected without benefit of standardization or reference to the concepts and potential capabilities of national data-buoy systems, caused them to be considered inadequate for the design and development responsibility of the Coast Guard National Data Buoy Systems Designated Project Office (NDBS DPO). Therefore, a data requirements refinement effort was undertaken by TRC as one activity of Contract DOT-CG-82504-A. The objectives and scope of the data refinement effort were to obtain more up-to-date, complete, accurate, and clearly defined statements of marine meteorological and oceanographic data requirements from the various government agencies and their affiliates. Although total operational and research data requirements were desired, slightly more priority was placed on clarifying and refining the data requirements of the operational activities from the Deep Ocean (DO)* and Coastal North American (CNA)** regions. In addition to the goals to update, expand, and refine the 1967 data base, standardization of terms and units was to be achieved and the concepts and sensing characteristics of tentatively proposed national data buoy "systems" were to be used as a reference framework in helping to establish the refined data requirements.

The general procedure for refining the 1967 data requirements has several phases. First, from the results of analysis of the 1967 statements of data requirements and the projected (5-yr) buoy state-of-the-art (SOA), a hypothetical data-buoy "system" was conceptualized for reference purposes. Second, an assessment was made of how well each set of data requirements would be met by this hypothetical "strawman system." Third, the results of this assessment, together with questions that arose during the analysis and assessment, were forwarded to the pertinent agencies with detailed instructions on how to use the material in the desired refinement action. Fourth,

*Beyond 400 n mi of North American Coast

**Within 400 n mi of North American Coast

responses, including answers to the questions, were analyzed, assessed and translated into NDBS requirements for the various marine regions. Finally, the refined data requirements were interpreted in terms of tentative data observation sites in potential NDBS networks for DO and CNA deployment zones. This procedure assumes that the statements of data requirements are the best available information and collectively represent the national interests. It is to be understood that data requirements will continue to evolve and will eventually be better defined when adequate data from the marine environment are available to the agencies for their use.

The general procedure described above for the refinement of data requirements is both the starting point and a portion of the cycle for refinement of system design involving analyses of cost effectiveness, relative values, cost benefits, technical and economic feasibilities, etc. As system development and implementation progress, data collection capabilities may advance; in turn, this would probably result in changes of data requirements. Other changes might be produced by the evolution of new or improved data uses. For example, improved prediction models might require sensing additional parameters and/or modifying spatial and temporal sampling, duration of observation, etc. Thus, the capabilities of a technically feasible and economically cost-effective system may have a feedback impact on the data requirements. As a starting point for conceptualizing a hypothetical data buoy "system" to be used as a reference framework for this data requirements refinement effort, pertinent results from the 1967 National Data Buoy Systems Feasibility Study Final Reports have been used (Refs. 1, 2, 3, 4, 5, and 6). The 1967 feasibility study produced two hypothetical data buoy "systems" for DO and CNA that were shown to be technically and economically feasible. Versions of these "systems" played a part in the 1967 feasibility study cost-effectiveness analysis and the preliminary technical development plan.

As a first step toward conceptualizing "system" sensing characteristics used in this study, the 1967 DO and CNA hypothetical "systems" were re-evaluated in light of further review of the 1967 requirements and 5-year buoy SOA estimates; the resulting modified DO and CNA "systems," described in Section 2.0, were used as part of the 1968 refinement of data requirements effort in the following manner. The participating U.S. Government agencies were given an assessment of the ability of the hypothetical "systems" to meet their 1967 stated data requirements. The agencies were requested

to refine their stated data requirements and comment on the suitability of hypothetical "system" sensing characteristics for meeting their statements of data requirements. The agencies were encouraged to recommend changes in the characteristics of the "strawman system," and also to suggest sensing hardware or techniques that might be used in a data buoy system to collect data related to their required parameters.

The USCG NDBS DPO, assisted in part by TRC, solicited the relative importance of stated requirements for parameters and observing levels from four primary agencies with operational missions: Bureau of Commercial Fisheries, ESSA, U.S. Coast Guard, and U.S. Navy. This effort was initiated in mid-1968 when the preliminary results of the data requirements refinement effort were provided to the NDBS DPO by TRC. During the interim period of six months between the initiation of refined data requirements and the estimation of relative values of parameters and observing layers, some modifications to stated agency requirements developed. Therefore, what might appear as minor conflicts between the statements of refined data requirements and the tentative statements of relative values are, in fact, the normal results of the continued evolution of data requirements and the understanding thereof.

The technical approach for the refinement of the initial (1967) statements of data requirements is presented as a chronology in Table 1-1 and discussed in detail in Sections 2, 3, and 4. The geographical locations at which observations are required, according to the refined data requirements effort, are shown in Section 4 as tentatively proposed observation sites.* Section 5 presents estimates of relative importance of required parameters and observing layers to four agencies with operational missions. The conclusions of this study, highlighting reasonable initial NDBS common data sensing characteristics are given in Section 6. Suggestions for further study of the data requirements are presented in Section 7.

*Proposed observation sites are based on achieving (for the most part) required horizontal spacing of data observations within designated geographical areas. The precise latitude and longitude for each data collection site will probably be determined at some future time through coordination of agency requirements as they exist at that time.

TABLE 1-1
CHRONOLOGY OF 1968 REFINEMENT OF NATIONAL OPERATIONAL AND
RESEARCH MARINE ENVIRONMENTAL DATA REQUIREMENTS

Month (1968)	Major Activity	Date (1968)	Other Activities
Feb.	{ Analysis and assessment of 1967 data requirements statements and preparation for data requirements refinement meeting		
Mar.		↳ 19 Mar.	Data requirements refinement meeting
Apr.	{ Analysis and assessment of refined 1968 national data requirements statements	↳ 8 Apr.	Target date for return of refined requirements
May		↳ 15 May	Last refined operational requirements returned
June	{ Applicability of hypothetical NDBS "system" to refined requirements	↳ 29 May	Preliminary briefing for NDBS DPO
July		↳ 26 June	Formal briefing for NDBS DPO
Aug.	{ Preliminary identification of required sensing characteristics at typical observational sites in specific geographical regions	↳ 2 Aug. ↳ 16 Aug.	Solicitation of estimates of relative values of parameters and observing layers Target date for return of relative value estimates
Sept.		↳ 10 Sept.	U.S.C.G. direction to proceed with final report, using 1967 statements for missing refined research requirements
Oct.	{ Final report preparation and review		

2.0 ANALYSIS OF 1967 DATA REQUIREMENTS

In the first step of the general procedure for obtaining refined statements of data requirements, the 1967 data requirements statements were carefully analyzed for completeness and consistency. Next, the re-evaluated 1967 data requirements were used as a basis for modifying the characteristics of 1967 DO and CNA hypothetical "systems." The resulting "system" was used to assess the applicability of the hypothetical NDBS sensing characteristics for 1967 data requirements. The "system" sensing characteristics and an assessment for each relevant statement of data requirements were provided to the agencies as background information for use in refining data requirements in 1968.

The time-phased block diagram in Fig. 2-1 gives a brief overview of the sequence of events leading to the 1968 Marine Meteorological and Oceanographic Data Requirements Meeting in Washington, D.C., on 19 March 1968. Briefly, the agencies were presented with a comparative analysis of what data requirements had been specified, where inconsistencies or anomalies seemed to be present in the 1967 statements of data requirements, and how it appeared (in March 1968) that data buoy "systems," representative of future National Data Buoy Systems, might be able to satisfy the agencies' requirements. The intent of this effort was to ensure that all agencies were aware of the impact of stated data requirements on the 1967 feasibility study results and the progress of USCG NDBS DPO development planning up to that time. The agencies were then requested to modify and refine their statements of data requirements, if desired.

Once the refined 1968 statements of data requirements were collected, a new assessment of requirements was performed and applicability of the hypothetical data buoy "systems" re-evaluated and the "systems" were modified, as judged advisable

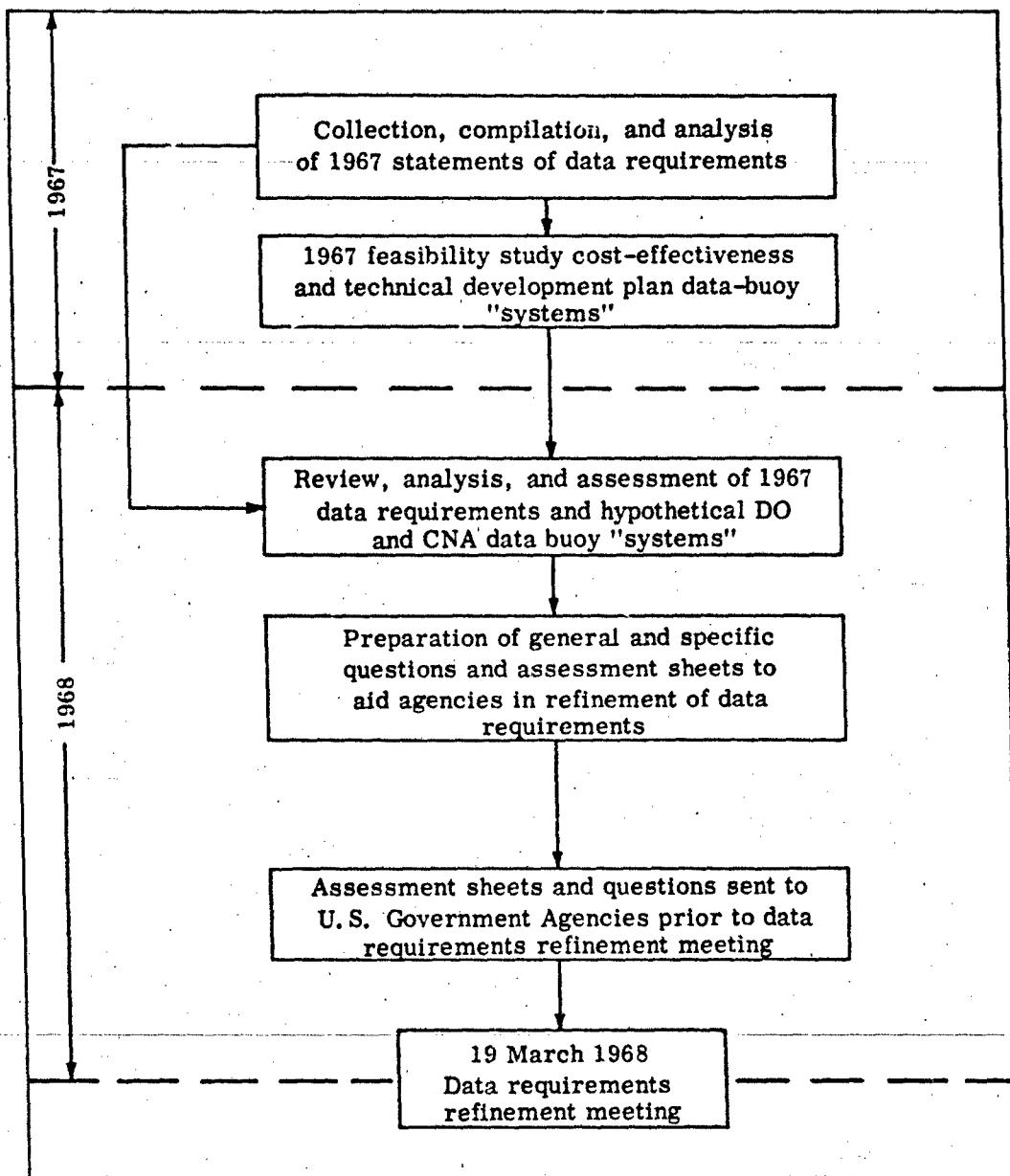


Fig. 2-1. Sequence of Events Leading to Refinement of National Marine Environmental Data Requirements by Federal Agencies

in the light of buoy 5-year SOA and economic feasibility.* This phase of the study is discussed in Sections 3 and 4.

2.1 Source Documents

During the first phase of the 1967 Study of the Feasibility of National Data Buoy Systems, the national requirements for marine meteorological and oceanographic data were collected and compiled. The carefully planned collection procedure, reported in the TRC Feasibility Study Final Report - Volume I, Part 1 [1], produced statements of data requirements tabulated on the original interview forms by the environmental scientists who conducted the interviews. These data were retabulated by the interviewers on simplified forms which were then returned to the various agencies for validation. Those 1967 statements of data requirements that were validated and returned by 78 Agency-Mission-Operations (AMOs) were considered the best available source documents for use in this 1968 analysis. The 78 AMOs are listed in Table 2-1 among the 97 originally contacted. The remaining 19 AMOs are listed as "No Stated Data Requirements." (This general category is not intended to preclude an interest in data.) In some instances, as this analysis of 1967 data requirements proceeded, there were apparent problems with the data on some of these validated tables and it was necessary to refer back to the original interview forms for further clarification of deficient information that had slipped through the validation process. Thus the validated tables, the original interview forms, and telephone contacts with agency representatives provided the best available source information for this first phase of the 1968 data-requirements refinement process.

*Of course, a "strawman system" can only be useful as a guide for undertaking more thorough systems analyses involving cost-effectiveness, technical and economic feasibility of equipment developments, relative values of parameters and observing layers, relative worth to the nation of agency missions, benefits derived from data use, etc. It is clear, however, that the procedure outlined here does provide a complete iterative cycle through the requirements/system development loop. It is possible that the acquisition of experimental data (e. g., from the BOMEX and NORPAC field experiments) may stimulate yet another refinement cycle through this loop. In general, assessment and refinement of marine environmental data requirements probably should occur at least annually.

TABLE 2-1
LIST OF AGENCY-MISSION-OPERATIONS (AMOs) CONTACTED

	Agency (activity)	Mission-operation (program)	Number code	Agency (activity)	Mission-operation (program)
01	U.S. Air Force— Air Weather Service	Support launch and recovery of space vehicles	36	Environmental Science Services Administration—Coast and Geodetic Survey	Prediction of tides and tidal currents
02	U.S. Air Force— Air Weather Service	Support national defense weapons and tactics RDT & E at Eglin AFB and Western Test Range at Vandenberg AFB	31	Environmental Science Services Administration—Coast and Geodetic Survey	Collection of geomagnetic data over the deep oceans
03	U.S. Air Force— Air Weather Service	Support global Dept. of Defense operations	32	Environmental Science Services Administration—Coast and Geodetic Survey	Collection of geomagnetic data over the continental shelf
04	State Dept.—Arms Control	No stated data requirements	33	Environmental Science Services Administration—Weather Bureau	Global general weather analysis and prediction
05	U.S. Army—Coastal Engineering Research Center	Research in coastal engineer- ing	34	Environmental Science Services Administration—Weather Bureau	Marine weather analysis and prediction
06	U.S. Army—Lake Survey	Water motion research in the Great Lakes	35	Environmental Science Services Administration—Weather Bureau	World Weather Watch analysis and prediction
07	Atomic Energy Commission— Headquarters, Washington, D.C.	No stated data requirements	36	Environmental Science Services Administration—Institute of Oceanography	Research in ocean circula- tion-estuary, near shore and deep ocean studies
08	Bureau of Commercial Fisheries—Galveston	Research on water masses in the Gulf of Mexico	37	Environmental Science Services Administration—Institute of Oceanography	Research in ocean circula- tion-air/sea interaction studies
09	Bureau of Commercial Fisheries—Tropical Atlantic Biological Laboratory, Miami, Florida	Research on Tuna in Tropical Atlantic, Caribbean and Gulf of Mexico	38	Environmental Science Services Administration—National Environmental Satellite Center	No stated data requirements
10	Bureau of Commercial Fisheries—Beaufort, N.C.	Research on North American menhaden and blue crab on the cont. shelf from Maine to Texas	39	Department of the Interior— Federal Water Pollution Control Administration	Study on pollutant amounts and control
11	Bureau of Commercial Fisheries—Beaufort, N.C.	Research on North American menhaden and blue crab in estuarial and near shore from Cape Cod to Texas	40	Department of Health, Educa- tion, and Welfare—Water Supply and Sea Resources Program	Research on effect of pollu- tants on shellfish
12	Bureau of Commercial Fisheries—Seattle, Washington	Research on commercial fish in the North East Pacific and off the North West Coast of N. America	41	Department of Commerce— Maritime Administration	No stated data requirements
13	Bureau of Commercial Fisheries—Stanford, California	Research on air/sea inter- action in the Pacific	42	National Aeronautics and Space Administration	No stated data requirements
14	Bureau of Commercial Fisheries—La Jolla, California	Distribution and environment of tuna, anchovy and sardine in the Eastern Pacific	43	National Science Foundation— University of Rhode Island	No stated data requirements
15	Bureau of Commercial Fisheries—Woods Hole, Mass.	Research on major ground fish species of the New England Coast	44	National Science Foundation— Duke University	Research in Gulf Stream structure and dynamics
16	Bureau of Commercial Fisheries—Booth Bay Harbor, Maine	Research on herring, lobster and sardine—off shore in the Gulf of Maine	45	National Science Foundation— Duke University	Research on metabolic and growth rate of marine organ- isms
17	Bureau of Commercial Fisheries—Booth Bay Harbor, Maine	Research on herring, lobster and sardine—near shore in the Gulf of Maine	46	National Science Foundation— Duke University	Study of life and source of life in oceanic abyss
18	Bureau of Commercial Fisheries—Environmental Oceanographic Research Program, Washington, D.C.	Research on bottom fish off Cape Cod	47	National Science Foundation— University of Miami	Research on oceanographic environmental parameters and under-water acoustical propagation
19	Bureau of Commercial Fisheries—Washington, D.C.	Synoptic Climatology for Bureau of Commercial Fisheries' use	48	National Science Foundation— University of Miami	Study current in South Florida waters—determine transport of shrimp
20	Bureau of Sport Fisheries— Sandy Hook Marine Lab., N.J.	Fish distribution on cont. shelf of east coast	49	Office of Naval Research— University of Miami	Research on oceanographic environmental parameters and equatorial current system
21	Bureau of Sport Fisheries— Tiburon Marine Lab., Calif.	Fish distribution on cont. shelf of west coast	50	National Science Foundation— University of Miami	Marine Biology—no stated data requirements
22	Department of the Interior— Bureau of Mines, Tiburon, California	Develop marine mining tech- nology	51	National Science Foundation— Oregon State University	Research on wind stress on the ocean off the Oregon Coast
23	U.S. Coast Guard	Ocean station vessels	52	National Science Foundation— Lamont Geophysical Observatory	Bottom current measurements in deep basins of the Pacific
24	U.S. Coast Guard	Data acquisition along standard sections	53	National Science Foundation— Lamont Geophysical Observatory	Observations of the Antarctic polar front
25	U.S. Coast Guard	Ice Patrol monitoring	54	National Science Foundation— Lamont Geophysical Observatory	Current measurements along sills—renewal of water in deep basins
26	U.S. Coast Guard	Ice Patrol research	55	National Science Foundation— Lamont Geophysical Observatory	Monitor currents along shelf of Weddel Sea
27	U.S. Coast Guard	Search and rescue			
28	U.S. Coast Guard	Oceanographic Services			
29	U.S. Coast Guard	Icebreaking-polar ocean- ography			

TABLE 2-1 (Continued)

Number code	Agency (activity)	Mission-operation (program)	Number code	Agency (activity)	Mission-operation (program)
56	Office of Naval Research—New York University	General circulation of the oceans	84	Office of Naval Research—Scripps Institution of Oceanography	Research on the large-scale fluctuations of the oceanographic and meteorological conditions of the North Pacific
57	Office of Naval Research—New York University	Air/Sea interaction—emphasis on wave forecasting	85	Atomic Energy Commission—Scripps Institution of Oceanography	Research on near-bottom currents in the Pacific
58	National Science Foundation—Woods Hole Oceanographic Institution	Study dynamic processes of the Western North Atlantic	86	Office of Naval Research—Woods Hole Oceanographic Institution	Research on Gulf Stream
59	National Science Foundation—University of Washington	Study of the effluent waters of the Columbia River	87	Office of Naval Research—Nova University	Measure of velocity field and mass field in strong currents
60	National Science Foundation—University of Washington	No stated data requirements	88	Naval Undersea Warfare Center (code D003)	Research on underwater sound propagation patterns
61	National Science Foundation—Texas A & M	No stated data requirements	89	U.S. Navy—NAVAIRSYSCOM (AIR-8401)	Developing analysis and forecasting techniques to support Naval Weather Service
62	Smithsonian Institution—Washington, D.C.	No stated data requirements	90	Federal Aviation Administration	No stated data requirements
63	U.S. Navy—Chief Naval Operations	No stated data requirements—Included in Naval Weather Service—Nos. 71 and 72	91	Department of the Interior—Geological Survey	No stated data requirements
64	U.S. Navy—Radiological Defense Laboratory	No stated data requirements	92	National Science Foundation—Massachusetts Institute of Technology	Research on general circulation of the atmosphere and oceans
65	U.S. Navy—Mine Defense Laboratory	Mine defense including inshore underwater sea warfare	93	National Science Foundation—Massachusetts Institute of Technology	Research on internal gravity waves
66	Naval Oceanographic Office—Anti-submarine Warfare Environmental Prediction Services	Oceanographic environmental prediction techniques—research, development, test and evaluation	94	National Science Foundation—Massachusetts Institute of Technology	Research on Rossby waves
67	NOO-Hydrographic Surveys Dept. (code 50)	Inshore surveys (except North America)—measure depth of water to 400 fathoms	95	National Science Foundation—Massachusetts Institute of Technology	Research on air/sea boundary layer
68	NOO-Deep Ocean Surveys Division (code 50)	Underwater environmental monitoring to provide data for test ranges	96	National Oceanographic Data Center	No stated data requirements
69	NOO-Deep Ocean Surveys Division (code 50)	Environmental surveys of large areas of the world oceans	97	Naval Civil Engineering Laboratory	No stated data requirements
70	NOO-Exploratory Oceanography (code 70)	Provide Navy with information for use in sound transmission problems	98	Bureau of Commercial Fisheries—Honolulu	Basic water mass studies
71	Naval Weather Service—Airborne	Support airborne operations	99	Bureau of Commercial Fisheries—Atka Bay, Alaska	Research on environment of fish in Alaskan waters
72	Naval Weather Service—Oceans	Support water surface and subsurface operations			
73	Pacific Missile Range—Point Mugu, Calif.	Support Pacific missile range			
74	Applied Physics Laboratory—University of Washington	No stated data requirements			
75	Naval Ordnance Laboratories—White Oak, Maryland	No stated data requirements (Requirements met by NOO—code 50, Nos. 68 and 69)			
76	Ordnance Research Laboratories—Penn. State University	Research on large-scale factors affecting transmission of underwater sound			
77	Ordnance Research Laboratories—Penn. State University	Research on small-scale factors affecting transmission of underwater sound			
78	Naval Oceanographic Office—Instrument Center (code 60)	No stated data requirements			
79	U.S. Navy—Marine Engineering Laboratory	Testing of deeply submerged machinery			
80	U.S. Navy—Marine Engineering Laboratory	Measure normal geomagnetic noise			
81	U.S. Navy—Underwater Sound Laboratory	Acoustic raypath studies			
82	Naval Ship Research and Development Center	Test sea-worthiness of ships			
83	Office of Naval Research—General Motors Defense Research Laboratory	No stated data requirements			

*Added during refinement program.

2.2 Comparative Tabulations

The goals of this phase of the 1968 analysis of the 1967 statements of data requirements were:

- (1) To determine how the sensing characteristics of these statements compared with each other, and
- (2) To use the 1967 statements of data requirements to validate or modify the sensing characteristics of the hypothetical "systems" postulated during the 1967 NDBS feasibility study.

As a means toward achieving these goals, comparative tabulations were prepared for the statements of data requirements from both operation and research activities. To keep these comparative tabulations as simple as possible, only certain required key "system" characteristics and only those parameters judged to be measurable by buoys were included, because it was a reference data buoy "system" that was needed. The required range and accuracy for each parameter, although key characteristics, were too variable to include on this simple comparative data tabulation sheet, so they were compared separately, both against each other and against the 5-year projected buoy state-of-the-art (SOA). To obtain the projected 5-year buoy SOA measurement capability, including the parameters as well as the ranges and accuracies, reference was made to the 5-year buoy SOA. (See Table 3-1, Ref. 1.) The various terms for similar parameters were collapsed into one primary form and standardized units of measurement were established. This and other pertinent information is presented in modified form here as Table 2-2. Using this table to determine the parameters that were considered measurable by buoys and their measurement category, the comparative tabulations of the 1967 operational and research data requirements were prepared as Tables 2-3 and 2-4 respectively.

The comparative tabulations (Tables 2-3 and 2-4) present the specification of the 1967 data requirements by AMOs, as interpreted by TRC, in a form for easy comparison. The details on the characteristics of the data requirements are at the left of the table; details on required parameters are at the right of the table. More complete definition of the AMOs listed in the first column of these tables is given in Table 2-1. Under requirement characteristics, the geographical locations from which data are

required (in columns 2 and 3 of Tables 2-3 and 2-4) and the spacing of the requirements in the horizontal (columns 4 and 5) are broken down into the Coastal North American (CNA) and Deep Ocean (DO) regions. In the preparation of this information (columns 2, 3, 4, and 5), the validated specifications for these characteristics were charted as a check of the completeness of the statements. These graphic displays of the stated characteristics, including the resultant number of required buoys, are similar to the ones for the refined data requirements presented in Appendix III.

The vertical layer from which observations are required and the vertical spacing of the observations in those layers are presented in the 6th and 7th columns. The duration (or discrete time span) required for a single measurement of a parameter and the frequency with which observations are required are entered in the next two columns. Of the last three columns of requirement characteristics, the first two cover the synchronization (or total allowable time lapse among supposedly simultaneous observations), both in the horizontal (a geographical region) and vertical (down a line of ocean sensors and up into the atmosphere). Finally, the last column shows the total period of time over which the observational program will be required.

TABLE 2-2
PROJECTED 5-YEAR BUOY STATE-OF-THE-ART (SOA)

Parameters measurable by buoys	Requirement		Layer required			Projected 5-year buoy SOA					
	Operational	Re-search	Ocean	Surface	Atmosphere	Pot'l tech. prob.	Better by non-buoy	Units	Range		Accuracy
									Min.	Max.	
PRIMARY (Observed)											
1. AIR TEMPERATURE	X	X		X				degrees C	-25	60	0.1°C
2. ALBEDO		X		X		X		percent	0	100	10 pct
3. AMBIENT LIGHT	X	X	X					ly/min	0	2.0	1 pct
4. AMBIENT NOISE	X	X	X					db (ref $P_0 = 1 \text{ dyne/cm}^2$)	-80	-20	3 db
5. ATMOS. ELECTRICITY	X			X				k volts	0	10	.01 kv
6. ATMOS. PRESSURE	X	X		X				millibars	800	1099	0.1 mb
7. BATHYMETRY	X	X	X			X		meters	5	10,000	2 m

TABLE 2-2 (Continued)

Parameters measurable by buoys	Requirement		Layer required			Projected 5-year buoy SOA				
	Operational	Research	Ocean	Surface	Atmosphere	Pot'l tech. prob.	Better by non-buoy	Units	Range	
									Min.	Max.
8. BIOLOGICAL GROWTH	X	X	X			X	X			
9. BOTTOM PHOTOGRAPHY	X		X			X	X			
10. CARBON DIOXIDE		X	X			X		atmos	10^{-4}	12×10^{-4}
11. CURRENT DIRECTION	X	X	X	X				degrees	0	360
12. CURRENT SPEED	X	X	X	X				knots	0.05	10
13. DEW POINT	X	X		X				degrees C	-25	40
14. ELEC. VOL. CONDUCTIV.	X	X	X					mmho/cm	10	60
15. GRAVITY	X			X		X		mgals	$.95 \times 10^6$	10^6
16. ICE ACCUMULATION		X		X		X		inches/hr	0	6
17. INCLINATION		X	X			X		degrees	0	90
18. INSOLATION	X	X		X				ly/min	0.01	2.0
19. MAG. FLD. DECLINAT.	X	X	X	X		X		degrees	0	180
20. MAG. FLD. INCLINAT.	X	X	X	X		X		degrees	0	180
21. MAG. FLD. INTENSITY	X	X	X	X		X		gammas	10^4	10^5
22. OXYGEN	X	X	X			X		ml/liter	0.5	9
23. pH	X	X	X			X		pH units	.1	13
24. PRECIPITATION RATE	X	X		X				inches/hr	0	12
25. PROPAGATION LOSS	X		X			X	X	decibels	10C	10 ke
26. RADIOLOGICAL CHEMICALS	X		X			X				
27. SEDIMENT DEPOSIT	X		X			X	X	feet		
28. TIDAL FLUCTUATION	X	X	X	X		X		feet	0	60
29. TOTAL CLOUD AMOUNT	X	X			X	X	X	percent	0	100
30. TOTAL RADIATION IN		X		X				ly/min	0.01	2

TABLE 2-2 (Continued)

Parameters measurable by buoys	Requirement		Layer required			Projected 5-year buoy SOA					
	Operational	Re-search	Ocean	Surface	Atmosphere	Pot'l tech. prob.	Better by non-buoy	Units	Range	Accuracy	
								Min.	Max.		
31. TOTAL RADIATION OUT		X		X		X		ly/min	0.01	2	1 pct
32. TRANSPARENCY	X	X	X					pct/meter	0	70	2 pct
33. TURBIDITY	X	X	X			X		parts/ml	1	1000	1 pt/ml
34. VERTICAL CURRENT		X	X			X		knots	0.1	0.8	0.05 knots
35. VISIBILITY	X			X		X		naut. mi	0.1	20.0	0.2 n. mi or 10^7
36. WATER LEVEL		X		X		X		feet	-30	-30	0.1 ft or 2 pct
37. WATER PRESSURE	X	X	X					psi	0	10^4	0.1 pct
38. WATER TEMPERATURE	X	X	X	X				degrees C	-5	40	0.01°C
39. WAVE DIR. SPECTRUM		X		X		X		degrees	0	360	5°
40. WAVE HEIGHT	X	X		X				feet	0	100	0.2 ft or 10 pct
41. WAVE PERIOD	X	X		X				seconds	1	40	0.1 sec or 1 pct
42. WIND DIRECTION	X	X		X				degrees	0	360	2°
43. WIND SPEED	X	X		X				knots	0	160	0.5 kts 3 pct
<u>Added in 1968 Refinement</u>											
MOORING LOAD		X	X					pounds	0	15,000	5 pct
PICTURES OF FISH	X	X	X			X					
SUB SFC. INSULATION		X	X			X		ly/min	0	2.0	1 pct
<u>SECONDARY (Derived)</u>											
1. INTEGRATED WIND FORCE	X			X		X		dynes/cm ²	0	10^7	10 pct
2. INTEGRATED WIND SPEED	X			X		X		knots	0	160	0.5 kts or 3 pct
3. RESULTANT WIND DIR.		X		X		X		degrees	0	360	10°
4. RESULTANT WIND SPEED		X		X		X		knots	0	87	0.5 kts or 3 pct

TABLE 2-2 (Continued)

Parameters measurable by buoys	Requirement		Layer required			Projected 5-year buoy SOA					
	Op'rational	Re-search	Ocean	Surface	Atmo-sphere	Pot'l tech. prob.	Better by non-buoy	Units	Range		Accuracy
									Min.	Max.	
5. SALINITY	X	X	X	X				parts/thousand	0	42	0.01 ppt
6. SEA STATE	X	X		X		X	X	code	0	9	1
7. SOUND SPEED	X	X	X					feet/sec	4500	5800	1 fps
8. SPECIFIC HUMIDITY		X		X				grams/kgrams	0	20	0.1 gm/kg
9. WAVE DIRECTION	X	X		X				degrees	0	360	5°
Added in 1968 Refinement											
FOG		X		X							
WATER DENSITY		X	X								
Parameters beyond 5-year buoy SOA											
1. Air Density	X				X						
2. Biological Parameters	X	X	X								
3. Bottom Sampling	X	X	X								
4. Chemical Parameters	X		X								
5. Chlorophyl	X	X	X								
6. Cloud Base	X				X						
7. Cloud Top	X				X						
8. Cloud Type		X			X						
9. Cosmic Radiation	X				X						
10. EH		X	X								
11. Flux-heat	X			X							
12. Flux-mass	X	X	X	X							
13. Flux-momentum	X	X	X	X							
14. Flux-water Vapor		X		X							
15. Ice Breakup		X			X						
16. Ice Crystal Size	X				X						
17. Nitrates		X	X	X							
18. Nutrients	X	X	X								
19. Ozone	X				X						

TABLE 2-2 (Continued)

Parameters beyond 5-year buoy SOA	Requirement		Layer required			Parameters beyond 5-year buoy SOA	Requirement		Layer required		
	Operational	Research	Ocean	Surface	Atmosphere		Operational	Research	Ocean	Surface	Atmosphere
20. Phosphates		X	X			30. Sediment Rate		X	X		
21. Plankton	X	X	X		X	31. Silicate		X	X		
22. Propagation Loss (U/A)	X				X	32. Stability		X		X	
23. RAOB (T, P, RH)*	X				X	33. Vertical Motion	X				
24. Rawin (wind)*	X	X			X	34. Visibility (U/A)	X				
25. Rawinsonde (T, P, RH, V)*	X	X		X	X	35. Vorticity Comp. (x,y)		X		X	
26. Refractive Index	X			X	X	<u>Added in 1968 Refinement</u>					
27. Reynolds Stress		X		X		Dust		X		X	
28. Sediment Load		X	X			Toxic or Trace Metals		X	X		
29. Sediment Movement		X	X								

*Advancements are being made in upper-air soundings from ocean surface platforms - probably humidity, pressure, and temperature will be available first.

On the right-hand side of the comparative tabulations, the required parameters considered measurable by buoys are presented in three measurement categories. These categories are: first, the parameters that were judged in the 1967 Feasibility Study to be most cost-effectively measured from buoys; next, a subgroup of that first group for which there appear to be potential technical problems; and, finally, the group of parameters that are probably better measured from some platform other than buoys.

These comparative tabulations, plus the information on required ranges and accuracies of parameter measurements, present the best available information delineating the 1967 data requirements in a concise and manageable form. This information was used as a basis for developing sensing capabilities concepts of the tentatively proposed (for a reference framework) data-buoy "system."

2.3 Tentatively Proposed NDBS Sensing Characteristics

To determine the sensing characteristics of a hypothetical data buoy "system" to be used as a reference for the refinement of data requirements by the agencies, the comparative tabulations of operational and research requirements (Tables 2-3 and 2-4)

TABLE 2-3. COMPARATIVE TABULATIONS OF 1967 OPERATIONAL DATA REQUIREMENTS

AMO	Geographical Location		Horizontal Spacing		Vertical Layer	Vertical sampling intensity	Duration of observation	Time sampling intensity	Requirement Characteristics		Permit of Operation
	CNA	DO	CNA	DO					#	y	
#1 USAF(AWB)	Z & W Test Range recovery areas & areas near Hawaii and ~ 30°N, 80°W		100 to 200 mi		800	N/A	Inst, 5 min Inst, 10 min	3 hrs	1 hr	N/A	Cont, 5 days at a time
#2 USAF(AWB)	N. Gulf of Mex. Lines from 28°N, 85°W Single pts. at 30°14'N 96°32'W & 33°N, 86°W		100 to 300 mi 100 mi N/A (2 pts)		800	N/A	Inst, 5, 10 min Inst, 5 min Inst, 5, 10 min	3 hrs A/R 3 hrs	1 hr N/A 1 hr	N/A	Cont, 3 days at a time
#3 USAF(AWB)	Global		300 to 600 n. mi		Bfc thru shel	50 m	Inst	12 hrs	30 min	Not stated	Cont.
#14 RCP-LaJolla	Pacific Coast 30°S to Alaska	Pacific coast to 140°W, 30°S to Alaska	60 to 120 n. mi	60 to 120 n. mi	Bfc to 500 m (transp) Bfc to 100 m	Std levels (transp) Unk	5 min 60 min Unk (transp)	6 hrs	30 min	5 min	Cont.
#19 RCP-Wash., D. C.	Pacific Coast 30°S to Alaska	Pacific Coast to 160°E, 30°S to Alaska	60 to 240 n. mi	60 to 240 n. mi	Bfc to 600 m & bot	Std levels	Not stated	6 hrs	30 min	5 min	Cont.
#23 USCG-OBV	OBV "B" at 56°N, 51°W	3 OBV in N. Atl. 2 OBV in N. Pac.	N/A (2 pts)	N/A (5 pts)	Bfc to near bottom	0.5, 10, 25, 50, 100, 200, 500 & on 500 m (W pres) bfc & DO	30 min	6 hrs	30 min	30 min	Cont.
#24 USCG-Sid. Sect.	7 Tracks in Atl. 6 Tracks in Pac.	5 Tracks in Atl. 6 Tracks in Pac.	10 mi > 150 60 mi > 150	60 mi	Bfc to near bottom		30 min	6 hrs	30 min	30 min	Cont.
#25 USCG-Ice Patrol	Grand Banks of Newfoundland		10 to 30 mi		Bfc to near bottom		10 to 10 min	6 hrs	30 min	30 min	Cont Feb.-July
#27 USCG-SAR	Ocean areas contiguous to the U.S.		Varies w/o per		Bfc to near bottom		30 min	Varies w/o per	30 min	30 min	Intermit 2 wks
#28 USCG-Oceans - Services	Line ~ 50 mi off E. Cat. Lines in U.S. shelf	Wide areas Atl. Land areas Pac.	100 mi 300 mi		Bfc to nr bot Bfc		10 to 10 min 30 min	6 hrs	30 min	30 min	Cat Bia Cont. other ~ 30 days
#29 USCG-Ice Breaking		Arctic & Antarctic		Not stated	Bfc to near bottom		30 min	6 hrs	30 min	30 min	Cont. 2 mo. at a time
#30 C&G-C&G (R&D)	Estuaries & near shore Cont. shelf	Offshore - N. Pac. only Deep Ocean	3 mi 3 to 1000 mi 100 mi	(Tide = 300 mi) 1000 mi	Bfc to bot ↓	10 m 10 m 650 m	6 min ↓	6 min ↓	15 days 45 days 6 mo	3 min ↓	Cont
#31 ESRA-C&G (S&G)		Deep Ocean		2000 mi	Bfc or within 30 m	N/A	3 sec	1 min	2 min	N/A	Cont. not in opere yet
#32 ESRA-C&G (S&G)	Cont. shelf		3 to 300 mi		Bfc or within 30 m	N/A	3 sec	1 min	2 min	N/A	
#33 ESRA-WB	N.A. Cat < 400 n.mi	400 n.mi from N.A.	60-100, 20-50 n. mi	200 to 500 n. mi	Bfc to unknown	50 m 50 m	Inst or short per	1 hrs 12 hrs	10 min 16 min	1 min	Cont
#34 ESRA-WB	N.A. Cat < 400 n.mi	>400 n.mi from N.A.	60-300, 10-100 n. mi	200 to 500 n. mi	Bfc to unknown	50 m 50 m	Inst Inst	3-1 hrs 12 hrs	10 min 16 min	1 min	Cont
#35 ESRA-WB(WWW)		Global		300 to 600 n.mi	Bfc down thru shel	50 m	Inst	12 hrs	30 min	Not stated	Cont
#39 PWPCA	Great Lakes Coastal estuarine & Puget Sound		1 Buoy ea. 400, 4, 1/4 sq mi		Bfc to bottom	0, 30, 60, 90 and each 60 m	1 min 5 min	1 hr	1 hr	10 min	Cont. some are 7 mo./yr
#47 NOD-Code 90		to 600 m depth-BI Areas S.A., Afr., Eu, Afr.		Single pts	Bfc to bottom	N/A	Inst	1 ob site (Tide 1 hr)	N/A	N/A	Cont. one time 3 mo.
#48 NOD-Code 90	Atlantic Test range -17°N, 61°W -18°N, 67°W -20°N, 158°W		1 to 10 pts 10 to 30 n. mi apart in ea. range	1 to 10 pts 10 to 30 n. mi apart in ea. range	Mixed layer to bottom	30 m thru shel, 600 m shel-up bot, 10 m or bottom	Inst 2 min Avg	5 min	1 min	3 min 5 min	Cont
#49 NOD-Code 90		Global		One site at a time	Varies	Cont. (Curt 1000 m)	Inst to 10 min	1 hr, shre once a site	3 min	3 min	Cont
#71 USN(NWR) Airborne		Global		300 to 600 mi	Bfc to 100K ft abv	1b to 60b, 2b to 70b, 5b to 100b ft	Inst (Integ. wind 10 min)	8 hrs	1 hr	1 hr	Cont
#72 USN(NWR) Sfc & Subfc		Global		300 to 600 mi	Bfc to bottom	Std IAPMO levels	Inst (Integ. wind 10 min)	12 hrs (Ocean) 6 hrs (Met)	1 hr	1 hr	Cont
#73 USN-PMR	Pt. Maga 33.5°N 120°W	Barking Sands 22°N 160°W	Varies Generally ~ 25 to 50 mi		Bfc to bottom (max 4752 m)	Cont.	Inst (Curt 30 min)	6 hrs	15 min	15 min	Cont/A max 4 days

* Varies with parameters.

† And integrated wind.

ERATIONAL DATA REQUIREMENTS

RATED SPINNING MAGNETY	Duration of observation	Time sampling intensity	Sync. of Obs. x, y z	Period of Operation	PARAMETER NOTE: BEST MET BY BUOYS													POTENTIAL TECHNICAL PROBLEMS	BETTER MET BY NON-BUOY	
					Lat/long/bearing	Relative wind	Absolute wind	Atmospheric pressure	CURRENT DENSITY	Conductivity	Precipitation rate	Salinity	Sound speed	Temperature	Water pressure	Wind speed	Wind direction	Magnetic field	Atmospheric ice	
Not, 5 min 10 min	3 hrs	1 hr	N/A	Cont. 5 days at a time	x		x	x		x		x	x	x	x	x	x	x	x	
Not, 5, 10 min Not, 5 min Not, 5, 10 min	3 hrs A/R 3 hrs	1 hr N/A 1 hr	N/A	Cont. 5 days at a time	x		x	x		x		x	x	x	x	x	x	x	x	
Not	12 hrs	30 min	Not stated	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
5 min 40 min Unk (transp)	4 hrs	30 min	5 min	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
Not stated	4 hrs	30 min	5 min	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
25, 50, 1,500 & min	30 min	4 hrs	30 min	30 min	Cont.		x	x	x	x	x	x	x	x	x	x	x	x	x	
Not & Do					Cont.		x	x	x	x	x	x	x	x	x	x	x	x	x	
	30 min	4 hrs	30 min	30 min	Cont.		x	x	x	x	x	x	x	x	x	x	x	x	x	
	10 to 10 min	6 hrs	30 min	30 min	Cont. Pub - July		x	x	x	x	x	x	x	x	x	x	x	x	x	
	30 min	Varies w/oper	30 min	30 min	Interr 2 hrs		x	x	x	x	x	x	x	x	x	x	x	x	x	
	10 to 10 min 30 min 30 min	6 hrs	30 min	20 min	Cat Sta. Cont. others 30 days		x	x	x	x	x	x	x	x	x	x	x	x		
	30 min	6 hrs	30 min	30 min	Cont. 2 mo. at a time		x	x	x	x	x	x	x	x	x	x	x	x		
	6 min ↓	6 min ↓	15 days 45 days 6 mo	3 min ↓	Cont.		x	x	x	x	x	x	x	x	x	x	x	x	x	
	5 sec	5 min	2 min	N/A	Cont. not in oper yet		x	x	x	x	x	x	x	x	x	x	x	x		
A	5 sec	5 min	2 min	N/A	Cont. not in oper yet		x	x	x	x	x	x	x	x	x	x	x	x		
Not or short per.	3/1 hrs 12 hrs	10 min	1 min	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
Not	3/1 hrs	10 min	1 min	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
Not	12 hrs	10 min	1 min	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
Not	12 hrs	30 min	Not stated	Cont.	x		x	x		x		x	x	x	x	x	x	x	x	
0, 20 5 min	1 min 5 min	hrly	1 hr	10 min	Cont. some areas 1 mo/yr		x	x	x	x	x	x	x	x	x	x	x	x		
4	Not	1 ob/site (Tide 1 hr)	N/A	N/A	Cont. one time 3 mo								x					x		
Not, self-serv	Not 2 min Avg	5 min	1 min	3 min 5 min	Cont.		x	x	x	x	x	x	x	x	x	x	x	x		
900 m)	Not to 10 min	1 hr, three times a site	2 min	2 min	Cont.		x	x	x	x	x	x	x	x	x	x	(Int) x	x		
10, 20 to 10	Not (long, wed 10 min)	6 hrs	1 hr	1 hr	Cont.		x	x	x	x	x	x	x	x	x	x	x	x		
10	Not (long, wed 10 min)	12 hrs (Octano) 6 hrs (Met)	1 hr	1 hr	Cont.		x	x	x	x	x	x	x	x	x	x	x	x		
	Not (curr 30 min)	6 hrs	15 min	15 min	Cont. A/R max 4 days		x	x	x	x	x	x	x	x	x	x	x	x		

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TABLE 2-4. COMPARATIVE TABULATIONS OF 1967 RESEARCH DATA REQUIREMENTS

AMO	REQUIREMENT CHARACTERISTICS									
	Geographical Location		Horizontal Spacing		Vertical Layer	Vertical Sampling Intensity	Duration of Observation	Time Sampling Intensity	Sync. of Obs.	Period of Operation
	Continent N. A. (CNA)	Deep Ocean (DO)	CNA	DO						
#5 ACFTNC	N. A. Coast, Health & G.R. Lakes where depth \geq 125 m		300 mi		Sfc	N/A	Inst. to 1 mile	4 hrs	6 min	N/A
#6 US Army Lk Survey	Great Lakes		6 to 27.5 mi		Sfc to bottom	3 m	Inst. reveal—20 min	1 hr (revised hrs)	6 min	6 min
#8 BCF-Galveston	Gulf of Mex., Fla. Straits & Yucatan (22°N, 88° to 24°N, 91°W)		3 to 6.8 to 15.6 mi (12 Lanes of 20) 2 to 6 mi (Lane of 20)		Sfc to 500 m	0, 10, 50, 100, 200, 300, 400, 500 m	30 to 60 min avg	12 hrs	30 min	30 min
#9 BCF-Miami	Trop. Atl (not spec. areas) 20°N to 26°S (in spec. areas)		200—400 10—30 s. mi		Sfc to 500 m	(Currl) 100 m to 500 m (Currl) 50 m to 500 m	1 min avg 1 min avg	24/12 hrs 4/3 hrs	30 min	30 min
#10 BCF-Berlfort	Cont. Shelf and Estuarine Maine-Texas		100 to 200 mi		Sfc to bottom	20 m	1 to 10 min	Semi-monthly	24 hrs	30 min
#11 BCF-Berlfort	Selected areas Cape Cod to Tampa		30 to 60 60 mi		Sfc to bottom	20 m	1 to 10 min	24 hrs	6 hrs	30 min
#12 BCF-Seattle	W. Coast 42°N to 60°N out to 400 mi / U.S. Coast to 160°E	Pacific N. of 42°N	5 to 60 mi	10 to 170 mi	Sfc to bottom	IA PBO levels	Inst.	(Sfc—10 m) 12 hrs (10 m—bottom) 24 hrs	12 hrs	1 min
#13 BCF-Standard	West Coast of N. A.	Pacific N. of 20°S W. Ctl to 180°	Lanes very 60 to 100 mi	Lanes 100 to 300 mi	Sfc—400 m	7 to 73 levels	30 hrs	24 hrs	12 hrs	12 hrs
#15 BCF-Woods Hole	40°N to 45°N, 64°W to 74°W on Cont. Shelf No deep water or Gulf Stream		500' Part 100 to 300 a. mi Sub-Sfc Part 30 to 100 a. mi		Sfc to 2000 m (Currl) 50 m	3 m to 100 15 m below (Currl) 5 m	Inst. or medium term avg	2, 4, 12 hrs and 24 hrs	15 min	5 to 10 sec
#16 BCF-Beth Bay Harbor	Gulf of Maine offshore		25 to 30 mi		Sfc to 20 m	Closer near Sfc	Inst.	Cont. from 1—24 hrs	1 min	1 min
#17 BCF-Beth Bay Harbor	Gulf of Maine onshore		8 to 12 mi		Sfc to 20 m	Closer near Sfc	Inst.	Cont.	1 min	1 min
#18 BCF-West., D.C.	Cont. Shelf N. of Cape Hatteras, Maine		10 to 20 m contour		Sfc & bottom	N/A	Hourly & 4 hourly max and min	Cont.	15 min	N/A
#20 NSF-Study Hook	Cape Cod to Florida Keys (inshore)		2 mi in lines 2 to 10 mi long Lines from 10 to ~ 100 mi apart		Sfc to bottom	0 m	5 min (wind) 1 hr	1 hr (curr) 2 hrs	5 min	5 min
#21 BRF-Tiburon	Cont. Shelf West Cont. (3 areas) 32°N to 34°N, 36°N to 39°N, 45.4°N to 48.3°N		varies ~ 10 to 45 mi		Sfc to bottom	0, 10, 30, 50, 100 m	Inst.	1 hr	5 min	1 min
#22 Bureau of Mines	Selected areas of Alaska & W. Coast now. Off of Mexico & E. Coast 5—15 yrs	Atl & Pac Op Ocean in 5—15 yrs	Varies 1 to 50 mi could be 1 mi	Unknown	Sfc to bottom	Std levels	Inst to unknown	3 to 12 hrs & unknown	24 hrs	6 hrs
#23 USCG-Ice Patrol	Grand Banks, Labrador Sea,	Baffin Bay	10 to 30 n. mi	10 to 30 n. mi	Sfc to air bottom	0, 5, 10, 20, 50, 100, 200, 500 m, etc.	30 min	4 hrs	30 min	30 min
#31 ERDA-CAGB (S&G)	Deep Ocean		2000 mi	At Sfc or within 20 m	N/A	0.1 sec	Cont.	5 sec	N/A	Cont. for 1 yr not yet started
#32 ERDA-CAGB (S&G)	Cont. Shelf		200 to 300 mi	At Sfc or within 20 m	N/A	0.1 sec	Cont.	5 sec	N/A	Cont. for 1 yr not yet started
#33 ERDA- IO	E. Coast estuaries & near shore—(Chesapeake Bay, Potomac)	Deep Ocean—(Gulf Stream, Caribbean)	1 to 3 mi	1 to 6 mi	Sfc to 5000 m	10 to 20 levels	1 min	30 min	5 min	5 min
#37 ERDA- IO	Tropics & Sub-Tropics		100 n. mi	Sfc	N/A	10 min	1 hr	30 min	N/A	Term. date unknown
#40 NERF-	Cont. Shelf and Estuaries		2 to 3 mi or 1 per estuarine or fish area		Top, mid & bottom	Top, mid, & bottom	Inst	1 hr	N/A	N/A
#44 NERF-Duke U.	N. Car. Coast \leq 100 mi out to G. Stream		5 to 10 n. mi in lines 5 to 10 n. mi apart		Sfc to 2000 m	25 m	1 min	12 hrs	10 min	10 min
#45 NERF-Duke U.	Pt. at 34°N and 70°W	Pt. at 19°50'N and 66°20'W	1 Pt. only	1 Pt. only	bottom only	N/A	Inst	1 hr	N/A	N/A
#46 NERF-Duke U.	Pt. at 34°N and 70°W	Pt. at 19°50'N and 66°20'W	1 Pt. only	1 Pt. only	Sfc to bottom	100 m	1 min	1 hr	N/A	N/A

*Varied with parameter.

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DATA REQUIREMENTS

Duration of Observation	Time Sampling Intensity	Sync. of Obs.	Period of Operation	PARAMETER NOTE: BEST MET BY BUOYS												POTENTIAL TECHNICAL PROBLEMS	BETTER MET BY NON-BUOY	
				Air temperature	Relative humidity	Atmospheric electricity	Cloudiness	Current velocity	Wind speed	Wind direction	Wind gusts	Wind shear rate	Wind pressure	Wind turbulence	Wind visibility			
inf. to 1 hr	4 hrs	0 min	N/A	Cont.														
1 hr	1 hr (newest 1 hr)	0 min	6 min	1 min./yr inf. free	x													
0 to 60 min	12 hrs	30 min	30 min	Cont.														
min avg	24/12 hrs	30 min	30 sec	Cont.	x													
min avg	6/3 hrs				x													
to 10	semi-monthly	24 hrs	30 min	Cont.														
10 to 100	24 hrs	6 hrs	30 min	4 min./yr Cont.														
100	(0 to -10 m) 12 hrs (10 m - best) 20 hrs	12 hrs	1 min	Cont.														
1 hrs	24 hrs	12 hrs	12 hrs	Cont.					x	x	x	x	x	x	x	x		
10	2, 6, 12 and 24 hrs	18 min	5 to 10 sec	Cont.				x	x	x	x	x	x	x	x	x		
100	Cont. 0 to 24 hrs	1 min	1 min	Cont. 20 days at a time				x	x	x	x	x	x	x	x	x		
1000	Cont.	1 min	1 min	Cont.	x			x	x	x	x	x	x	x	x	x		
10000	Cont.	10 min	N/A	0/45 to 0/47 min Cont.				x	x	x	x	x	x	x	x			
100000	1 hr every 2 hrs	5 min	5 min	Aug - Nov End 11/00				x	x	x	x	x	x	x	x			
1000000	1 hr 50	5 min	5 min	Cont. End 1971				x	x	x	x	x	x	x	x			
10000000	3 to 12 hrs & unknown	30 hrs	4 hrs	Cont. Term. date unknown				x										
100000000	0 hrs	30 min	30 min	Intense longest period 30 days				x	x	x	x	x	x	x	x	x		
1000000000	Cont.	5 sec	N/A	Cont. for 1 yr not yet started														
10000000000	Cont.	5 sec	N/A	Cont. for 1 yr not yet started														
100000000000	20 min	5 min	5 min	Intense 3 min. at a time				x										
1000000000000	30 min	5 min	5 min	Term. date unknown				x										
10000000000000	1 hr	30 min	N/A	Cont. not yet started				x										
100000000000000	12 hrs	10 min	10 min	Cont. Intense Brake				x										
1000000000000000	1 hr	N/A	N/A	Cont. for -3 yrs not yet started				x										
10000000000000000	1 hr	N/A	N/A	Cont. for -2 yrs not yet started				x										

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TABLE 2-4 (Continued). COMPARATIVE TABULATIONS OF 1967 RESEARCH DATA REQUIREMENTS

AMO	REQUIREMENT CHARACTERISTICS										
	Geographical Location		Horizontal Spacing		Vertical layer	Vertical Sampling Intensity	Duration of observation	Time sampling intensity	Stack of Obs.		Period of Operation
	CNA	DO	CNA	DO					S.	V.	
#47 NRP-U. of Miami	E. Coast of N.A. S of 40°N, W of 70°W, E of 90°W	0° to 40°N, W of 70°W & E of 90°W	- 8 mi. in Fla. Strait, rest unk	Unk	Sfc to bottom	25, 50, 100, 150, 200 & each 150 m (i.e., temp var w/ depth)	Int to 1 min avg	Unk	5 min	1 min	Cont.
#48 NRP-U. of Miami	23°N to 26°N and 74°W to 42°W		Selected areas unk		Sfc & bot	N/A	Int./short per avg	8 hrs	5 min	5 min	Cont.
#49 NRP-U. of Miami		12°N to 12°S in Atl. & Pac. Oceans	17°-17°5 15 mi 17°-2°N & 830 mi ~50 mi. fr. curr. ~300 outside curr	Sfc to ~500 m Sfc to 5000 m	0, 10, 30, 50, unk for lower levels	Unk	1 per day		Not stated		Cont. 1 to 2 yrs then move
#51 NRP-Oregon St. U.	100 mi sq centered at 45°N, 125°W		Unk		1/4-200 m 1/4-152 m above	5 levels Unk	5 to 20 min unk	Varied cont.	5 min	Unk	Cont. 8 mos. no winter
#52 NRP-Lamont Geophys. Obs	Deep stagnant basins in the Pacific			1-3 hours per basin 50 km apart	Bottom 1400 meters	25 m or. bot 50 m higher	< 10 sec	30 min	N/A	2 min	Cont w/ breaks not in operation yet
#53 NRP-Lamont	Antarctic Polar Front Region		15 to 30 mi to 250 mi line	Sfc to 250 m	25 m	1 min	1 hr	30 min	2 min		
#54 NRP-Lamont	Gibraltar, Caribbean, Venezuela Basin		1 hour per basin	Bottom	N/A	< 10 sec	30 min	N/A	N/A		
#55 NRP-Lamont	Along shelf of Weddell Sea	100 mi apart in lines ~ 200 mi long (3 lines)	Bottom	N/A	10 sec	15 min	2 min	N/A			
#56 NRP-NYU	East Coast & Gulf Stream	World Oceans	200 to 300 mi 20 mi in strong curr	200 to 300 mi 20 mi in strong curr	Sfc to bottom	600 m	20 min avg	6 hrs	2 hrs	2 hrs	Cont. not yet started
#57 NRP-NYU	East Coast & Gulf Stream	World Oceans	200 to 300 mi 20 mi in strong curr	200 to 300 mi 20 mi in strong curr	Sfc to ~1000 m	0-20 m to 15 levels var. to 1000 m	20 min avg	6 hrs	2 hrs	2 hrs	
#58 NRP-Woods Hole	Area N of 32°N, E of 15°W, W of 65°W and S of 40°N	20°N to 40°N and 65° to 75°W also Global Moorings of opportunity	6 s. mi. in Gulf Stream 20 s. mi. outside Gulf Stream	Unk	Log spacing limited by mooring (variable)	Int to 3-1/2 min avg	1 hr	10 min	10 sec	Cont.	
#59 NRP-U. of Wash.	Columbia River to 600 mi W, 300 mi S and 200 mi N	NE Pacific 40°N to 49°N 14°W to CNA	3 to 25 mi	3 to 25 mi	Sfc to 50 m	0, 3, 6, 9, 12, 15, 20, 25, 30, 40, 50 m	10 min	2 hrs	10 min	1 min	Cont. - 1971
#62 Smithsonian I.	Not stated	Not stated	10 mi	10 mi	Sfc to 200 m	3, 6, 12, 18, and 200 m	Not stated	48 hrs	Not stated	Cont. not yet started	
#63 USN-Mine Det. Lab.	Gulf of Mex. near Panama City out to 500 ft depth		Sfc-10 mi Sub-Sfc 1/4 mi over 1 mi		Sfc to bot Bot max 200 m	Each 8 and 16 m	Int to 20 min record	2 sec to 3 hrs	5 sec to 5 min	1 min to 5 mins	Cont.
#64 NOD-AEW EPS	Gulf Stream	Major currents in N. Hemis. Outside major currents N. Hemis.	30, 50, 200 300 & 400 n. mi	30, 50, & 400 n. mi. 80, 200, 300, & 400 n. mi.	Sfc to bottom	12 m int 300 m, 300 m from 300 m to bot.	Int to 5 min avg 20 min avg	6 to 12 hrs	20 min	5 min	Cont.
#70 NRL-NOC Code 79	1 pt., 33°30'N and 71°30'W (selected pts will vary in future)	1 pt., 23°30'N and 72°30'W	1 pt.	1 pt.	Sfc to 5500 m	- 22 levels	Int to 50 sec avg	1 hr 10 min	10 sec	10 sec	Cont. w/ breaks 6 mo-1 yr End FY 73
#76 ORL-Penn. St.	Gulf Stream	World Oceans (primarily major currents)	60 to 300 mi	60 to 300 mi	Sfc to bottom ~5000 m or 6000 m	10, 15, 30 & each 30 m	2 min	6 hrs	N/R	1 min	Cont.
#77 ORL-Penn. St.	Key West area		3 above - 1 1/2 mi apart in a line		Sfc to bottom ~5000 m	20 levels denser near trip	Cont.	Cont.	A few sec	A few sec	Cont.
#79 USN-Mar. Eng. Lab.	East Coast & Caribbean Sea (World wide later on)	1 pt. at a time	1 pt. at a time	Bottom to 16 m above bot. max 310 m	Bottom & 1.5, 3, 4.5, 6, 9 & 16 m abv bottom	1 min	30 min	N/A	1 min	Cont. w/ breaks 3 yr in an area	
#80 USN-Mar. Eng. Lab.	Cont. Shelf (depths > 150 ft) deeper water within telemetry distance of land	4 buoys in a 30 mi sq	Not stated	1 sensor	Cont.	Cont.	Milli-sec	N/A	2 min	Cont. length unknown	
#81 USN- (ISL)	Block Island Sound	South of Bermuda out to 150 mi	3 buoys 9 mi apart in a line	Varies	Sfc to bottom	14 ft (Block Island) Unk. (Bermuda)	2 to 5 min 2 to 5 min	5 min Unk	Unk	Unk	Cont.
#82 D. T. Mod. Raft	Anyplace in North Atlantic or Pacific where sea state is 4 to 8	One pt.	One pt.	Unk	N/A	10 to 30 min	Cont.	N/A	N/A	Instant	
#84 ONR-Scripps Institute of Oceanography	Calif. curr. 22.5°N to Columbia River	20°N to 50°N and 170°E to 140°W 4TP, 4TN, 4VV	9 clusters of 4 buoys each-clusters ~1200 mi apart-buoys ~8 mi apart in cluster	Sfc thru upper thal	Blk levels	Int. to 1 hr	1 hr	N/A	2 min	Cont. End 1974	
#85 ONR-Scripps Inst. Ocean	Deep currents in the Pacific			Unknown	Near bottom	- 3 m off the bot plus other levels off the bot	bot	Unknown	N/A	N/A	Cont.

*Varies with parameters.

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F 1967 RESEARCH DATA REQUIREMENTS

STATION	Vertical Sampling Intensity	Duration of observation	Time sampling Intensity	Bands of Use	Period of Operation	PARAMETER NOTES BEST MET BY BUOYS													POTENTIAL TECHNICAL PROBLEMS					
						N.	T.	S.	Air temperature	Ambient light	Atmospheric pressure	Atmospheric velocity	Cloud point	Precipitation	Sound speed	Water surface	Wave measurement	Wind direction	Directional wave spectrum	Infrared surface radiation	Magnetic field intensity	Radio reflection and	Total fluctuation	Vertical current
25, 50, 100, 150, 200 8 each 150 m (w. temp var w/depth)	Inst to 1 min avg	Unk	8 min	1 min	Cont.	x													x					
N/A	Inst./short per avg.	4 hrs 34 hrs	5 min 30 min	5 min	Cont.														x					
0, 10, 20, 30, unk for lower levels	Unk	1 per day		Not stated	Cont. 1 to 2 yrs then move													x	x	x	x	x	x	
8 levels Coh	5 to 30 min unk	Varies cont.	8 min	Unk	Cont. 8 mos. no winter	x			x	x	x	x			x	x	x	x						
25 m or, but 30 m higher	< 10 sec	30 min	N/A	2 min	Cont. w/ breaks not in operation yet				x						x									
30 m	1 min	1 hr	30 min	2 min																				
N/A	< 10 sec	30 min	N/A	N/A																				
N/A	10 sec	15 min	2 min	N/A																				
900 m	30 min avg	6 hrs	2 hrs	2 hrs	Cont. not yet started				x		x	x	x	x	x	x	x	x	x	x	x	x	x	
0, 5, 10, 20 m 15 levels var. to-1000 m	30 min avg	6 hrs	2 hrs	2 hrs					x		x	x	x	x	x	x	x	x	x	x	x	x	x	
Log spacing dictated by mooring (variable)	Inst to 2-1/2 min avg	1 hr	10 min	10 sec	Cont.				x		x	x	x	x	x	x	x	x	x	x	x	x	x	
0, 3, 6, 9, 12, 15, 20, 25, 30, 40, 50 m	10 min	2 hrs	10 min	1 min	Cont. - 1971						x	x	x	x	x	x	x	x	x	x	x	x	x	
3, 65, 120, 190 and 260 m	Not stated	40 hrs	Not stated		Cont. not yet started																			
Each 5 and 10 m	Inst to 20 min record	1 sec to 3 hrs	5 sec to 5 min	1 min to 5 min	Cont.				x		x	x	x	x	x	x	x	x	x	x	x	x	x	
12 m lat 300 m, 300 m from 300 m to bot.	Inst: 5 5 min avg 30 min avg	6 to 12 hrs	20 min	5 min	Cont.				x		x	x	x	x	x	x	x	x	x	x	x	x	x	
- 22 levels	Inst to 50 sec avg	1 hr 10 min	10 sec	10 sec	Cont. w/ breaks 4 wks-1 yr End FY 73						x							x	x					
10, 15, 20 & each 30 m	2 min	6 hrs	N/R	1 min	Cont.	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
20 levels denser near top	Cont.	Cont.	A few sec	A few sec	Cont.	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Bottom & 1.5, 3, 4.5, 6, 9 & 10 m abv bottom	1 min	30 min	N/A	1 min	Cont. w/ breaks 1 yr in an area				x		x	x	x	x	x	x	x	x	x	x	x	x	x	
1 sensor	Cont.	Cont.	Milli- sec	N/A	Cont. length unknown																			
14 ft (Block Island) Unk (Bermuda)	2 to 5 min 2 to 5 min 20 min	5 min Unk Unk	Unk Unk	Unk Unk	Cont.				x	x			x	x	x	x	x	x	x	x	x	x	x	
N/A	10 to 30 min	Cont.	N/A	N/A	Intermit																			
Red levels	Inst. to 1 hr	1 hr	N/A	2 min	Cont. End 1974				x		x	x	x	x	x	x	x	x	x	x	x	x	x	
- 3 m off the set plus other levels off the bot	Inst	Unknown	N/A	N/A	Cont.				x															

B

TABLE 2-4 (Continued). COMPARATIVE TABULATIONS OF 1967 RESEARCH DATA REQUIREMENTS

AMO	REQUIREMENT CHARACTERISTICS									Period of Operation
	Geographical Location		Horizontal Spacing		Vertical Layer	Vertical Sampling Intensity	Duration of Observation	Time Sampling Intensity	Sect. of Obs.	
	Coastal N. A. (CNA)	Deep Ocean (DO)	CNA	DO						
#66 UNR-Woods Hole	East Coast 35°N to 45°N	35°N to 45°N 50°W to 75°W	In Gulf Stream 5 to 10 mi Out of Gulf Stream 10 to 80 mi		Sfc to bottom	Cont (desired) 1 hr at 200 m in layer	Inst	24 hrs	15 min	30 sec Cont.
#67 UNR-Nova U.	Gulf Stream	Strong current regions of world	0.1 of max stream or current width		Sfc to any depth	20 m	1 month averages	1 every 3 days	1 hr	Instant max 2 mo End - unk
#88 USN-Elec. Lab	100 mi circle out from San Diego		1 to 4 pts in 10 x 10 mi area		Sfc to bottom Bottom max 600 m	50 levels 7 m to 15 m apart	Inst, 10 min & 4 hrs	Not stated	8 min to 90 mins	Cont. End Feb 71
#89 USN-NAVAIR-SYCON	Gulf of Mexico N. A. Coast out to 150 n mi 15°N to 60°N	Pac. 0° to 30°N & 150°W to Asia, Atl. 0° to 30°N & 35°W to N.A., 30°N to 45°N & 15°W to 40°E, Antarctic 60°S to Pole	0.1, 30 to 60, 100 and 300 n mi		Sfc to 150 m 300 n mi x, y z Sfc to 500 m	30 m 100 m	Inst wind ~ 10 min if > 20 knots	2, 3, 12 hrs 10, 30 min	30 sec	Cont.
#92 NSF-MIT		World Oceans	# 1200 sites over oceans, more intense in strong wind, and curr. gradient		Sfc to bottom	Not stated Main interest just above & below thcl	15 min 24 hrs	12 to 24 hrs	15 min 1 hr	Not yet started Instant max 1 mo. End unk
#93 NSF-MIT		Tropical N. Atlantic	3 to 10 buoys in a 5 mi sq.		Sfc to bottom W. press Bot only	20 levels	10 sec W. press 10 sec & 15 to 20 min avg	24 hrs	8 min	10 sec Not yet started Cont. length 100 days
#94 NSF-MIT		Mid-latitude N. Atlantic	30 buoys in a 4° square 20 to 600 mi between sq.		Sfc to bottom	20 levels	5 min W. press 5 min & 15 to 20 min avg	24 hrs	8 min	10 sec Not yet started Cont. length 1-2 yrs
#95 NSF-MIT	Cape Cod near Buzzards Bay Light Station		1 pt only		Sfc to bottom (bot depth .15-.30 m) Sfc to 10 m above surface	-5, -10, -20, -50 cm -1, 2, 10, -20m -5, 10, 20, 50 cm -1, 2, 10 m	Inst. Cont. over 3 min per.	36 min	N/A	10 milli sec 3 mo / yr summer 3 day wk End - unk Maybe 69
#97 Naval Civil Eng. Lab	Vicinity Santa Barbara Channel Islands, Calif.		1 pt only		Sfc to bottom	10 levels	Std	6 hrs	N/A	Not stated 70-75 Cont. W. brks Max- 1 yr

*Varies with parameter.

A

7 RESEARCH DATA REQUIREMENTS

Vertical Sampling Intensity	Duration of Observation	Time Sampling Intensity	Sync. of Obs.		Period of Operation	PARAMETER RQTS. BEST MET BY BUOYS													POTENTIAL TECHNICAL PROBLEMS			
			X, Y	Z		Air temperature	Ambient light	Ambient sound	Atmospheric electricity	Atmospheric pressure	Current velocity	Ice point	Induction	Precipitation rate	Salinity	Sound speed	Transparency	Water pressure	Water temperature	Wave measurement	Wind velocity	Oxygen
out (desired) ob at 200 m to per	Inst.	24 hrs	15 min	30 sec	Cont.	x											x	x	x	x		
20 m	1 month averages	1 every 3 days	1 hr	1 hr	Start max 2 mo. End -Unk						x					x	x	x	x			
4 levels 1 m to 15 m art	Inst. 10 min 4 hrs	4 hrs	Not stated	5 min to 30 min	Cont. End Feb 71						x					x	x					
20 m	Inst wind = 10 min if > 20 knots	2, 3, 12 hrs	30 sec 10, 30 min	30 sec	Cont.	x				x	x	x	x			x	x					
100 m																					x	
4 stated in interest at above & low that	15 min 24 hrs	12 to 24 hrs	15 min 1 hr	Not stated	Not yet started instead max 1 mo. End Unk					x		x	x	x		x	x	x				
levels	10 sec W. press = 10 sec & 15 to 20 min avg	24 hrs	5 min	10 sec	Not yet started Cont. length 100 days					x		x		x	x	x						
levels	5 min W. press = 5 min & 15 to 20 min avg	24 hrs	5 min	10 sec	Not yet started Cont. length 1-2 yrs					x		x		x	x	x						
-10, -20, -50 cm 2, 10, -20m 10, 20, 50 cm 2, 10 m	Inst. Cont. over 5 min per.	30 min	N/A	10 milli sec	3 mo./yr summer 5 days/wk End -Unk Maybe 60	x				x	x					x			x			
levels	Std	8 hrs	N/A	Not stated	70-76 Cont. W/buks Max- 1 yr					x		x		x		x		x				

B

were used. Emphasis was given to operational requirements, because they were better defined and of longer term. Also, certain operational requirements were equivalent to some research requirements. In selecting sensing characteristics based on Tables 2-3 and 2-4, consideration was also given to commonality (or, redundancy) of data requirements and the technological feasibility of developing suitable sensing capabilities within the next five years. From this analysis emerged certain tentatively proposed NDBS sensing characteristics, most of which were comparable to those of the hypothetical data buoy "systems" used in various aspects of the 1967 feasibility study.*

The first step in developing the hypothetical "system" was the selection, using objective criteria, of parameters to be included. The criteria for including operationally required parameters were:

- (a) The parameter must be required by at least two AMOs, one of which must be for operational support over a broad expanse of ocean.
- (b) The parameters must be judged to be measured best by a data buoy sensing capability (as might be used in NDBS) that could be developed without encountering major technical problems, and
- (c) The details of the data requirement, including characteristics, must be clearly and completely specified.

*A principal difference between this "new" hypothetical "system" and those used in the 1967 feasibility study is that the "new system" was postulated as what a future NDBS might provide in the way of sensing capabilities in the DO and CNA regions. The 1967 "systems" were proffered as having sensing capabilities that would satisfy the stated 1967 requirements, while at the same time they were shown to be economically and technologically feasible. In short, the question to the agencies in 1968 was, "Given a set of hypothetical data buoy "system" sensing characteristics, what would your statement of data requirements be?" As will be seen in later sections in this report, this approach served well in clarifying data requirements, and in addition helped make the agencies more aware of USCG NDBS DPO development efforts.

This led to the selection of 20 parameters proposed for the tentative "system" sensing capabilities. These parameters include eight meteorological and twelve oceanographic parameters as follows:

Meteorological

- Air temperature
- Atmospheric electricity
- Atmospheric pressure
- Dew point
- Insolation
- Precipitation rate
- Wind direction
- Wind speed

Oceanographic

- Ambient light
- Ambient noise
- Current direction
- Current speed
- Salinity
- Sound speed
- Transparency
- Water pressure (depth)
- Water temperature
- Wave and swell:
 - Direction
 - Height
 - Period

For convenience, these parameters were listed under the heading "Best Met by Buoys" on the final version of these comparative tabulations (Tables 2-3 and 2-4). The required parameters not selected by the criteria for inclusive are listed in the tabulations under "Potential Technical Problems" and "Better Met by Non-Buoys"** and should be classified as potential additional parameters whose inclusion in the tentatively proposed "system" is in question (here termed "grey area"). The reasons for non-inclusion of these "grey area" parameters are given in Appendix I, Part A (e.g., Bathymetry - better done by moving ships). Some required parameters that were

*NDBS service ship capabilities are involved here.

temporarily set aside because they were considered beyond the 5-year buoy SOA are listed in Table 2-2.*

The required range and accuracy characteristics for each of the twenty selected parameters were the same as, or slightly less stringent than, the corresponding projected 5-year buoy SOA. The 5-year SOA estimates for range and accuracy met all the operational and many of the research requirements for the twenty parameters; hence, the appropriate 5-year SOA values from Table 2-2 were proposed for the tentative NDBS sensing characteristics. The other requirement characteristics were proposed as a result of commonality analysis of the 24 sets of operational requirements presented in Table 2-3, with consideration given to the similarities and differences of the research requirements (Table 2-4).

The results of this commonality analysis (Table 2-3) are as follows. Of the 24 AMOs with operational requirements (see col. 1, Table 2-3), there were 20 requiring data from the Deep Oceans (col. 3) and more than half of these had large areal ocean or global requirements. Of the 20 AMOs requiring data from the Deep Ocean, 11 also required data from Coastal North America (col. 2). In addition, there were 4 other AMOs that required data from CNA only, resulting in a total of 15 AMOs requiring data from CNA. In the 57 sets of research requirements (Table 2-4), 36 were applicable in DO and 21 in CNA, but with very few exceptions the research requirements applied to limited areas of the oceans in support of particular studies. In performing commonality analysis using Table 2-3, the horizontal spacings (cols. 4 and 5 of Table 2-3) were established at 100 nautical miles ($n\text{ mi}$) in the CNA and 500 $n\text{ mi}$ in the DO, as was also done in the 1967 feasibility study. These values are for the convenience of analysis, since an actual data-buoy network would not be uniformly spaced but would conform to the variability of the parameters.

In performing a commonality analysis to determine the vertical layers from which data were required, it was found that the stated need for observational data extended

*At the time of this assessment in early 1968, the development within 5 years of an operational upper-air sounding capability for unmanned data buoys operating unattended for long periods was not deemed feasible. Experimental results later in 1968, however, indicate that development of rocketsondes for automatic launch from unmanned buoys may be possible within that time frame. Thus, future assessments of the capabilities of data buoy systems to meet marine environmental data requirements may also include upper-air soundings.

from the bottom of the ocean to 100,000 feet in the atmosphere. However, the extent of the depths from which data were required was often vague. For example, a number of AMOs implied, but did not clearly define, the need for bottom observations. (The details of required measurements in the vertical and bottom observations were requested in answers to explicit questions sent to the agencies for clarification during the 1968 refinement process.) About two-thirds of all operational and research requirements expressed need for data from the surface to 1,000 m depth; over half the requirements extended essentially to the bottom. As in the 1967 feasibility study, it was decided to tentatively consider the vertical layer from the surface (top of the buoy mast) to a depth of 5,000 m (which includes the bottom depth in over 80 percent of the oceanic area). In the vertical the required sampling intensities varied widely, but 20 standard IAPSO* levels were judged reasonable (in view of buoy SOA and costs) for the tentatively proposed "system."

For the conceptual "system," the time sampling intensity (frequency of observations) followed stated requirements of six hours for DO and three hours for CNA. This implies essentially real-time reporting. It was presumed that normal system flexibility would allow for more frequent data from particular areas when needed. The duration of observations, which varies with parameters, was proposed to be instantaneous or a representative short-period average of up to ten minutes. For the synchronization of observations (the allowable variation in actual time of observation), ten minutes was proposed in the horizontal and one minute was proposed for synchronization of observations in the vertical.

These values for the characteristics of parameter measurements were combined with the selected parameters and their required ranges and accuracies (referred to elsewhere as "max. error") to compile the tentatively proposed NDBS sensing capabilities (parameters and characteristics) summarized in Table 2-5. Some of the characteristics have values that are relatively constant for all the parameters; these are presented in the first part (A) of Table 2-5. The selected parameters and the values of the characteristics that vary with the parameters are presented in Table 2-5 B.

*International Association of Physical Scientists in Oceanography. The levels are: 0, 10, 20, 30, 50, 75, 100, 150, 200, 300, 400, 500, 600, 800, 1000, 1500, 2000, 3000, 4000, and 5000 meters. These levels were also used throughout the 1967 feasibility study.

TABLE 2-5
TENTATIVELY PROPOSED NDBS SENSING CHARACTERISTICS

A. "System" Sensing Characteristics having Relatively Constant Values

- Geographical Location: Deep Ocean (DO)/Coastal N. America (CNA)
out to 400 n mi
- Duration of Observation: Instantaneous or Representative Short-period Average up to 10 min
- Horizontal (x, y) Sampling Intensity: 500 n. mi. in DO/ 100 n mi
in CNA
- Time Sampling Intensity: 6 hr in DO; 3 hr in CNA
- Synchronization of Observations: 10 min in horizontal; 1 min in vertical

B. Parameters and Variable Sensing Characteristics

Parameters	Variable characteristics			
	Oceanographic	Range (5-yr SOA)	Accuracy (5-yr SOA)	Vertical layer
Current direction	0 to 360°	5°	Surface to 5000 m depth	20 standard IAPSO levels
Current speed	0.05 to 10 kts	0.03 kts* or 1%	Surface to 5000 m depth	20 standard IAPSO levels
Salinity	0 to 42‰	0.01‰	Surface to 5000 m depth	20 standard IAPSO levels
Sound speed	4500 to 5800 fps	1 fps	Surface to 5000 m depth	26 standard IAPSO levels
Water pressure (depth)	0 to 10 ⁴ psi	0.1%	Surface to 5000 m depth	20 standard IAPSO levels
Water temperature	-5 to 40°C	0.01°	Surface to 5000 m depth	20 standard IAPSO levels
Ambient light	0 to 2.0 ly/m	1%	Surface to 5000 m depth	2 levels
Ambient noise	-80 to -20 db	3 db	Surface to 5000 m depth	2 levels

TABLE 2-5
TENTATIVELY PROPOSED NDBS SENSING CHARACTERISTICS (Continued)

B. Parameters and Variable Sensing Characteristics (Continued)

Parameters	Variable characteristics			
	Range (5-yr SOA)	Accuracy (5-yr SOA)	Vertical layer	Vertical sampling intensity (Z)
<u>Oceanographic</u>				
Transparency	0 to 70%/m	2%	Surface to 5000 m depth	2 levels
Wave direction [†]	0 to 360°	5°	Water surface	1 level
Wave height [†]	0 to 100 ft	0.2 ft* or 10%	Water surface	1 level
Wave period [†]	1 to 40 sec	0.1 sec* or 1%	Water surface	1 level
<u>Meteorological</u>				
Air temperature	-25 to 60°C	0.1°C	Sea surface to mast top	1 level (representative)
Atmospheric electricity	0 to 10 kv	0.1 kv	Sea surface to mast top	1 level (representative)
Atmospheric pressure	800 to 1099 mb	0.1 mb	Sea surface to mast top	1 level (representative)
Dew point	-25 to 40°C	0.2°C	Sea surface to mast top	1 level (representative)
Insolation	0.01 to 2.0 ly/min	1%	Sea surface to mast top	1 level (representative)
Precipitation rate	0 to 12 in./hr	0.01 in./hr	Sea surface to mast top	1 level (representative)
Wind direction	0 to 360°	2°		
Wind speed	0 to 160 kts	0.5 kts* or 3%		

*Whichever is the greater value.

[†]Includes measurements of some swells (to 40 secs).

As an addition to buoy sensing capabilities — the primary subject to this point — there is the very important supplementary sensing capabilities of the service/buoy-tending ships, also an essential part of NDBS. These potential supplementary sensing capabilities of the buoy tenders include such parameters as:

Meteorological Parameters:

- Cloud base, tops and amount
- Surface visibility
- Rawinsonde data to 100,000 feet (press. height, relative humidity, temp., and wind)
- Refractive index
- Ozone

Oceanographic Parameters:

Surface

- Sea state
- Ice breakup

Subsurface

- Biological factors
- Chemical factors
- pH
- Radiological factors

Bottom

- Bathymetry
- Cores
- Photographs

2.4 Assessment of 1967 Data Requirements

The basic purpose for developing a hypothetical NDBS and defining its sensing characteristics was to obtain reference for assessing how well each individual set of data requirements would be met by the hypothetical but technologically feasible data buoy "system." To facilitate this work, a formal assessment sheet for 1967 data requirements was developed that indicated the tentative "system" sensing characteristics listed by parameters, at the top of the sheet with a corresponding space directly below for the data requirements of those same parameters for an AMO (see Table 2-6). Then, for each of the 20 parameters in the tentative "system," the characteristics of the data requirements of an individual AMO for that parameter could be entered below it in the appropriate column. Thus, for those 20 parameters, it was possible to assess very quickly, by inspection, how well the tentatively proposed "system" sensing capabilities could meet the needs of the AMO.

If the AMO required a parameter that was not included in the hypothetical "system" capabilities, it was not entered on this original assessment sheet.

TABLE 2-8 ASSESSMENT SHEET FOR 1967 DATA REQUIREMENTS

1. TENTATIVELY PROPOSED NDBS SENSING CHARACTERISTICS

OCEANOGRAPHIC										METEOROLOGICAL									
Parameters	Curr. dir.	Curr. speed	Saltinity	Sound speed	Water temp. (depth)	W. press. (depth)	Ambient light	Ambient noise	Trans- parency	Ht.	Per.	Dir.	Wave measurements*	Air temp.	Atmos. elect.	Dew point	Precip. rate	Wind dir.	Wind speed
Geographic location	Deep Ocean/N. Americas Coast out to 400 n. mi.																		
Vertical layer	Sfc. to 5000 m depth																		
Range (5 yr SOA)	0 to	0.05 to	0 to	4500 to	-5 to	0 to 10 ⁴	0 to 2.0	-50 to	0 to	0 to	1 to	0 to	-25 to	0 to	100 to	-25 to	0 to	0 to	
	360°	10 hrs	42.6/000	5000 fpe	40°C	μat	1/y/m	-20 dB	70°F/m	100 ft	40 sec	30°	60°C	16 hr	1095 mb	49°C	2.0 in./m	0 to	
Max error (5 yr SOA)	5°	0.03 hrs or 1%	0.016/00	1 fpe	0.01°C	0.17	V7	3 dB	27	0.2 ft	0.1 sec	5°	0.1°C	0.1 hr	0.1 mb	0.2°C	1%	0 to	
Duration of obs.	Inst. or Short period avg. (Representative)																		
Sampling Intensity	X, Y	> 500 n. mi./< 100 n. mi.											Sfc.						
Time	Z	20 Std. levels	(IAPR)										2 levels						
Obs. synch.	X, Y, Z	6 hrs./ 3 hrs.																	
	10 min. (1 min)																		

2. AMCY REQUIREMENTS

Geographic location																	
Vertical layer																	
Range																	
Maximum error																	
Duration of obs.																	
Sampling Intensity	X, Y																
Time	Z																
Synch. of obs.	X, Y																
	Z																

3. RESULTS OF ASSESSMENT

Requirements fully met:

Requirements partially met and why:

TABLE 2-6 ASSESSMENT SHEET FOR 1967 DATA REQUIREMENTS (Cont.)
 "GREY AREA" PARAMETERS NOW IN QUESTION FOR THE PROPOSED DATA BUOY SYSTEM

GREY AREA" PARAMETERS NOW IN QUESTION FOR THE PROPOSED DATA BUOY SYSTEM			
Parameter	X, Y	Z	Time
Can. location			
Vertical layer			
Range			
Maximum error			
Duration of obs.			
Sampling intensity	X, Y Z		
(in spec)	X, Y Z		

THE PROPOSED BUOY SYSTEM

PARAMETERS CONSIDERED BEYOND THE 5-YEAR STATE OF THE ART FOR THE PROPOSED BUOY SYSTEM	
Parameter	
Geo. location	
Vertical layer	
Range	
Maximum error	
Duration of ob.	
	X, Y
	Z
	Sampling intensity
	Time
	X, Y
	Z
Ob. sync.	X, Y
	Z
	Results

A second page was used for the details of the parameters that were required but could not be included for comparison on the first page (see Table 2-6, page 2). There were two categories of parameters not met by the tentative "system":

- Those that could be measured by buoys, but were not selected by the criteria for the proposed "system" (here termed "grey area" parameters), and
- Those that were considered beyond the 5-year buoy SOA.

Therefore, the second page of the assessment sheet provided space similar to that for the tentative "system"; at the top, for the details of the "grey area" parameter requirements and at the bottom, a corresponding space for those parameters considered beyond the 5-year buoy SOA.

The details of each of the 1967 data requirements were standardized (basic parameters and units) according to Table 2-2. Then the requirements information, in standardized form, was entered for a particular AMO for each parameter that could be put on the first page. An assessment was made of how well the hypothetical "system" sensing characteristics for the 20 parameters (Table 2-5) would meet the AMO's total requirements. The results of that assessment were tabulated at the bottom of the first page of the assessment sheet, in the following three categories:

- Requirements fully met: Required parameters having sensing characteristics requirements that could be fully met by the tentatively proposed hypothetical "system" were listed under this category.
- Requirements partially met: Required parameters having sensing characteristics requirements that could be only partially met by the tentatively proposed "system" were listed here. An explanation of why the sensing characteristics requirements could not be fully met was also given.
- Requirements not met and why: All required parameters having sensing characteristics requirements that could not be met by the tentatively proposed "system," and the reasons why, were given. All required parameters, other than the 20 proposed "system" parameters, appeared under this assessment category.

As the required parameters belonging in this last category were identified from the original source documents, the details of their requirements were entered on the

second assessment sheet. Whether they were "grey area" or "beyond the 5-year SOA" was judged from the material in Table 2-2 and Appendix I, part A.

The assessment sheets relayed all this information to the users as the primary step in the data requirements refinement process (example, Appendix I, part B). The assessment process also helped identify areas for general or specific questions and for selective need for clarification of the 1967 statements of data requirements.

2.5 Questions Derived from the 1967 Data Requirements

During the process of analyzing the 1967 data requirements, note was taken of the details of problem areas such as discrepancies, omissions, and insufficient information so that questions could be prepared and sent to the agencies for remedial action during the refinement process. After the assessments of the 1967 data were completed, all the notes on problem areas were accumulated and sets of formal questions were prepared. These questions were mailed to the agencies on forms with space left for the agency representatives to supply answers. Some of the problem areas leading to questions were common to many of the statements of data requirements while others were unique or pertained only to one or two of the AMOs. Thus, two sets of questions were prepared: (a) the general questions, for all the AMOs, which are included in Appendix I, part C and (b) the specific questions for individual AMOs, examples of which are presented in Appendix I, part D (for both operational and research AMOs).

There were five areas of analysis work, including upgrading source documents, preparing improved comparative tabulations, conceptualizing technologically feasible hypothetical "system" sensing characteristics, assessing 1967 data requirements, and preparing questions to challenge apparent data deficiencies; these constituted the major phases of the analysis of the previously collected 1967 statements of data requirements. The results of this analysis formed the informational basis for the data requirements refinement effort which, by its very nature, required the full participation of the appropriate representatives of the agencies and their affiliates as the users of the data.

3.0 REFINEMENT OF USERS' DATA REQUIREMENTS

The previous section described the re-assessment and analysis of 1967 statements of data requirements, and how the re-evaluation of hypothetical data buoy "systems" used in the 1967 feasibility study led to a somewhat revised hypothetical "system" that was used as a reference to assess the potential applicability of the NDBS to 1967 data requirements. Two questions were of primary importance at this point: (1) Did the agencies agree with the assessments; and (2) In the light of the potential of possible future NDBS sensing characteristics, did the agencies wish to refine, or otherwise alter, their statements of data requirements? A meeting of U. S. Government Agency representatives was scheduled for mid-March to solicit agency cooperation in answering these two questions and also clarifying or standardizing other elements in their data requirements statements.

3.1 Information Packages for Agency Representatives

Several weeks prior to the users' data requirements refinement meeting, pertinent information packages were prepared by TRC and forwarded via USCG channels to agency delegates (see list in Appendix I, part E). These information packages were sent with an explanatory letter from the NDBS Designated Project Office inviting the delegates and representatives to attend the meeting scheduled for 19 March 1968. Included in the packages were several relevant letters and technical papers for general information, the proposed program for data requirements refinement, the agenda for the meeting, and the specific assessment sheets for each Agency's AMOs with appropriate sets of questions. On the front of each of the sets of assessment sheets and questions were explanatory prefaces (see Appendix I, parts B, C, and D,) to assist the agency representatives in understanding the document and how it was to be used in the refinement process. The agency representatives were requested to review the material in the information packages to help inform and prepare themselves so that the refinement conference would be as productive as possible.

3.2 Conference on Refinement of Data Requirements

A conference for the refinement of data requirements was held on 19 March 1968 at the Departmental Auditorium, Washington, D. C., for the delegates and working-level representatives of Federal Government agencies having marine data requirements.

Numerous organizational and VIP observers were invited to attend also (see list in Appendix I, part F). The meeting was planned to encourage active participation by the attendees (see list in Appendix I, part G). The agenda included a background briefing by the NDBS DPO entitled "A System Approach to the Development of NDBS" (a progress report showing the relationship of requirements refinement to the total effort) and a briefing by TRC entitled "Examples of Comparison of the Variability of Natural Phenomena and NDBS Characteristics." The more specific briefings by TRC on the 1967 data requirements refinement included: "The Purpose of Refinement," "General Questions Arising from the Assessments," "Methodology for Refinement," "Specific Questions Arising from the Assessments," and "Methodology for Agency Assistance in Refinement." Question and answer periods were conducted between the briefings and at the conclusion of the formal meeting. As indicated by the titles of the briefings, the attendees were given detailed information and documentation on the nature of the 1967 data, the data requirements problems and inadequacies for the system development tasks that lay ahead, the general and specific aspects requiring refinement, how requirements refinement was to be accomplished, and what the agency representatives could do to help achieve that goal. After the attendees heard the general problem and the methodology for solution, they were asked specifically to review with their appropriate people the assessment sheets for their AMOs, the charted interpretations of their areas of data interests, and the sets of questions about deficiencies in the data base. They were requested then to take such action as necessary to answer the questions on their AMOs (in the light of all the new information), to check and correct as necessary the charted areas of data interest and, finally, to refine the statements of data requirements by correcting, as necessary, the data on their assessment sheets. Blank charts and assessment sheets were supplied for their use. In an effort to keep the refinement program on schedule, a deadline of 8 April 1968 was set for the refinement responses to be in the mail to TRC.

As a result of this refinement conference, the actual up-dating, expansion, and refinement of the 1967 statements of data requirements were placed in the hands of the agency delegates and representatives authorized and responsible to speak to the data requirements question.

3.3 Agency Responses for Data Requirements Refinement

The responses from the agencies were generally good; however, a few responses still left problems unsolved and questions unanswered. Replies were supposed to be received at TRC during the second week of April, but only a small percentage were. The final agency operational requirements response was received a month late; about 20 per cent of the research activities had not responded at the time of writing this report. These facts affected the schedule for analysis of refined data requirements. To obtain a complete set of requirements, the 1967 data requirements of the non-responsive research activities were considered still valid and a temporary part of the total refined data requirements. These 1967 data requirements are identified in Appendix IV which contains all the assessment sheets with the refined statements of data requirements.

During this refinement process, two new sets of data requirements (AMOs 98 and 99) covering research activities in the Bureau of Commercial Fisheries (BCF) Biological Laboratories in Alaska and Hawaii were received and added to the list in Table 2-1. A number of responses from research activities (AMOs 45, 46, 48, 52, 53, 55, and 95) indicated that their 1967 data requirements should be withdrawn or were no longer valid since the research had been completed, or the principal investigator had departed (or was working on something else) or felt his requirements inappropriate for NDBS development. In certain other cases, requirements for particular types of data were dropped; e.g., ESSA deleted their estuarine requirements and their magnetic field requirements. Another feature of the ESSA response was that all nine of the AMO requirements were collapsed into one statement of data requirements for the agency, showing combined total operational and research data needs.

4.0 ANALYSIS OF REFINED DATA REQUIREMENTS

Agency responses, made directly to TRC, were logged in, evaluated, and the pertinent information extracted and entered into the appropriate operational or research comparative tabulations (see Appendix II). These tables, similar to the ones discussed in Section 2.2 for the 1967 data, served to organize the refined requirements for easy reference, comparison, and checking of quality and completeness.

The changes made in the data requirements during refinement are indicated (by large dots) on these charts. Inadequacies noted in the refined data were resolved by telephone. Late responses caused scheduling difficulties for the remaining work and those not in by late July 1968 were assumed satisfactory in their 1967 form, to provide a more comprehensive data base.

4.1 Assessment of the Refined Data Requirements

One of the requests to the agency representatives was to chart the area from which they required data. This was to eliminate any errors in translation of a verbal description of the geographical area. Several agency representatives did comply with this request but a considerable number did not. Therefore, to be sure that all descriptions of the geographical areas were adequate, charts were prepared by TRC delineating the areas from which it was understood data were required for each activity. These charts, in many cases showing TRC's interpretation of the area of data interest, are contained in Appendix III for all operational and research requirements. When it was considered necessary, clarification and/or additional information were obtained from the agencies by telephone.

An additional source of refinement input from the agency representatives was answers to the general and specific questions that had been sent. Their answers were supposedly reflected in the information on the maps and the statements of refined data requirements on the assessment sheets that were included in their responses. However, the responses in all the other material were checked for consistency with these answers to the questions. Since the set of general questions (Appendix I, part C) pertained to aspects of conceptual formulation of the tentative "system" sensing characteristic, an analysis was made of the answers received from both operational and research activities. These answers indicate the reaction of the various users to the

tentatively proposed sensing characteristics for the DO and CNA regions of the NDBS. Although there naturally was some variability in the answers, the summary indicated a high acceptance of, and a general shift to, most of the proposed measurement characteristics. These "system" characteristics include range, accuracy, vertical sampling intensity, and duration of observations. There was also an apparent general acceptance of proposed measurement of 20 parameters, since during refinement there were many parameters from among these 20 that were added to the original requirements.

In addition to the Deep Ocean and Coastal North American regions, an important new point of agreement was a clearer definition of the third data source region; a Near-Shore region defined as within 25 n mi of the shore (CNA is defined as the ocean region 25-400 n mi off shore). This Near-Shore region would include estuaries and would thus include pollution and recreational activities. Thus, three regions (DO, CNA, and Near-Shore) present the potential for having three different buoy networks in which the spacing between the buoys would most likely be of different scales (progressively finer).

Surprisingly few equipment suggestions for measuring "grey area" parameters were returned although suggestions for applicable sensing equipment had been specifically requested. The need for a limited number of observations at or near the bottom, usually up to a stated maximum depth, was indicated by the responses. Suggestions were made recommending a number of transect lines in CNA, perpendicular to the coast, but spaced up to a few hundred n mi apart (rather than a uniform grid). Concern was also shown for the horizontal spacing of observations in certain areas of the CNA, where significant changes can occur over short distances. These were the significant points that were brought out in the answers to the general questions.

After the information for areas of data interest and answers to the sets of questions were evaluated, the rest of the refined data requirements on the assessment sheets (which, in a sense, has been validated by the agency representatives and checked upon receipt by TRC) were accepted as correct at this time. The results of assessments at the bottom of the sheets were checked for completeness and accuracy after the refined data requirements were accepted as the best available. These assessment sheets for the 1968 refinement of the data requirements are presented in completed

detail in Appendix IV. These represent the most accurate and detailed statements of the refined data requirements available at this time. Another facet of the assessment was to update and refine, within feasibility limits, the details of the hypothetical reference "system" sensing characteristics (e. g., see the discussion below of the modification of horizontal spacing). There will doubtless be a continuing refinement process as the requirements evolve. The latest version of the hypothetical "system" sensing characteristics appears at the top of the refined data assessment sheets (App. IV) and resulted from assessing the refined data requirements and then modifying the hypothetical "system."

One problem that was resolved in this manner was the horizontal spacing of observations. The NDBS sensing capabilities proposed for assessing the original 1967 data had a spacing of 500 nautical miles in DO and 100 nautical miles in CNA. The 500 n mi spacing was finer than the desired spacing of some requirements but was used to meet the requirements of others for which it was the largest acceptable spacing. During the requirements refinement there was some relaxation by agencies in the required spacing, making 600 n mi a plausible value, at least for the initial system and until enough data are obtained and used to form a basis for better specification of DO spacing requirements. Because this would mean (at least initially) a reduced number of data locations required and thus reduced costs, the two most concerned agencies (ESSA and BCF) were contacted by telephone and the agencies agreed that 600 n mi was a suitable value to consider for the initial "system."

Similarly, for the CNA region, the 100 nautical miles spacing originally proposed was considerably finer than the lowest acceptable spacing of the refined data requirements for the agencies having broad or total areal coverage. After telephone conversation it was agreed to reduce the number of required data locations by having the first line of buoys start at 25 n mi from the U. S. and Canadian coasts and spaced 100 n mi apart, and then relaxing that spacing until, at 400 n mi from the coast, the buoys would be spaced 150 n mi apart, as indicated in Fig. 4-1. In the remainder of the CNA region, off the Mexican coast, the first line of buoys would start at 100 n mi off the coast and the spacing would relax to 150 n mi at 300 and 400 n mi off-shore (see Fig. 4-2).

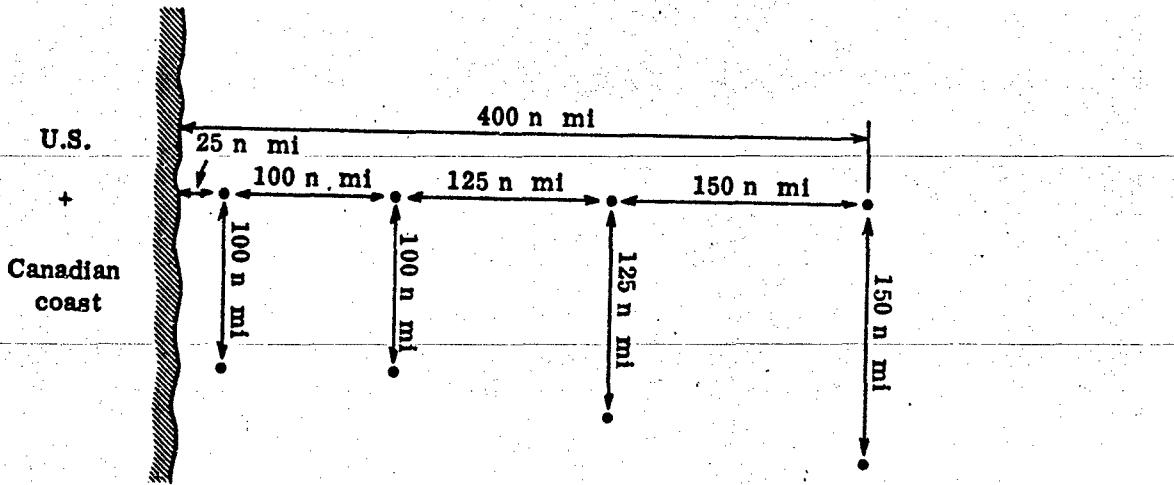


Fig. 4-1. CNA horizontal spacing along U.S. and Canadian coasts.

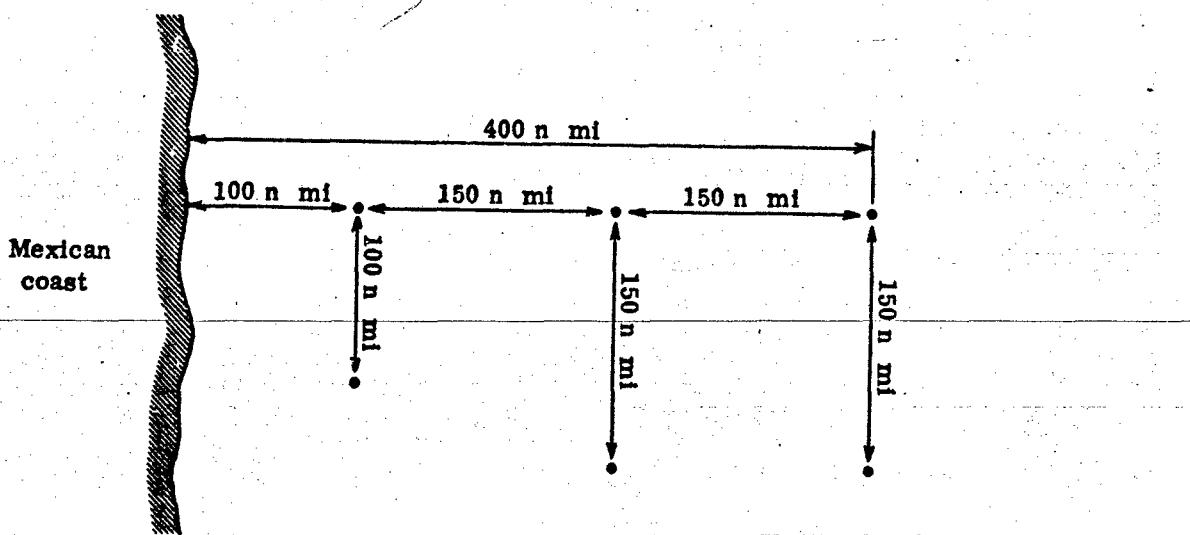


Fig. 4-2. CNA horizontal spacing along western Mexican coast.

This CNA horizontal spacing exemplifies a non-uniform grid and would provide finer scale observations of the environment where it more closely affects the national interests of the U.S. These revised values for the horizontal spacing requirements for DO and CNA are included in the latest version of the tentatively proposed NDBS sensing capabilities at the top of the assessment sheets, in Appendix IV, which represent the reference "system" against which the assessment of the refined data requirements was made.

4.2 Analysis of Refined Operational Data Requirements

The analysis of the refined operational requirements was undertaken first, because all were available by mid-May and the research ones were not all returned. Perhaps more importantly, it must be kept in mind that there is justification on the basis of national benefits for the NDBS to try to meet operational requirements as soon as possible. For the purpose of this analysis, the refined data requirements for the different AMOs of a given agency that had been through the assessment process were collapsed into one set representing the data needs of the whole agency. Thus, the summarized results of this analysis are in terms of refined Agency data requirements and are presented as follows. The net impact of the refinement process is expressed in terms of: (a) the parameters that had been added, (b) the changes in the measurement characteristics (performance envelope), as indicated in Appendixes II and IV, respectively, and (c) the applicability of the proposed "system" in meeting the refined data requirements (in terms of those requirements that would be fully met and those requirements that would not be met and why). In addition, the number of observation sites (buoys) required to meet the agencies' statements of refined data needs in the oceans from 60° N to 60° S is specified, and the geographical areas that they cover are shown on maps in Appendix III.

4.2.1 Individual Agencies

Summaries for each of the agencies requiring data to support operational activities follow in alphabetical order.

A. Bureau of Commercial Fisheries (BCF)

- Parameters added: none
- Three changes in characteristics (all conforming to "system" values).
 - (a) Horizontal spacing in DO: "600 n mi for initial buoy network."
 - (b) Vertical sampling: "IAPSO levels plus a bottom observation to maximum depth of 500 to 625 meters."
 - (c) Duration of observation: "10 minutes (representative average)."

- System applicability.
 - (a) Eight "system" parameters fully met: air temperature, wind velocity (2), current velocity (2), salinity, transparency, and water temperature.
 - (b) Three parameters not met: the scale of whole mile measurements of water temperature and salinity boundaries in CNA is too fine for proposed "system" spacing. The heights of 1000 to 700 mb surfaces were considered beyond the 5-yr SOA in this study.* The 60 minute (estimated) integrated wind observation for heat flux computations will probably not be satisfied without minor changes for the duration of observations in the proposed "system."

- Observation sites (buoys) required:

(a) 110 DO at 600 n mi spacing

290 CNA at 100-150 n mi spacing including an estimated 50
for fine scale observations

400 Total requirements.

*See footnote, Page 27 about upper-air soundings.

(b) 128 of the 400 occur at BCF sites supporting 1 BCF activity
(48 DO and 80 CNA)

136 of the 400 occur at BCF sites supporting 2 BCF activities
(31 DO and 105 CNA (observation sites))
— this equals approximately

(c) 264 Different observation sites (buoys) for BCF requirements.

B. Environmental Science Services Administration (ESSA)

- Four parameters added:
 - Dew point, precipitation rate, sound speed and water pressure (requirements for estuarine data were changed to N/A):
- Two changes in characteristics (all conforming to "system" values).
 - (a) Vertical layer: "surface (top of buoy mast) — 5000 m depth."
 - (b) Vertical sampling intensity: "20 IAPSO levels plus a bottom observation to maximum depth of 5000 m."
- System applicability:
 - (a) Fifteen parameters fully met: air temperature, atmospheric pressure, dew point, precipitation rate, wind velocity (2) current velocity (2), salinity, sound speed, water pressure, water temperature and waves (3).
 - (b) Five upper-air parameters not met: air temperature, atmospheric pressure, dew point, and wind velocity (2) to 100,000 feet.
- Observation sites (buoys) required:
 - 261 DO at 600 n mi spacing
 - 279 CNA at 100-150 n mi spacing
 - 540 Total observation sites (buoys) no common locations.

C. U.S. Air Force Air Weather Service USAF/AWS

- Nine parameters added:
 - Atmospheric electricity, dew point, insolation, precipitation rate, ambient light and noise, sound speed, transparency and water pressure.

- Four changes in characteristics (all conforming to "system" values):
Vertical sampling intensity, duration, frequency and synchronization of observations were all changed to comply with the "system."

- System applicability:

- (a) Twenty "system" parameters full met: Exceptions were 200 n mi spacing of a few buoys and the 3 hour frequency of observations in space vehicle recovery zones which, with minor "system" changes, could be met.

- (b) Nine upper-air parameters not met: Atmospheric pressure, cloud amount, density (derived), profiles (of humidity, temperature and wind velocity), propagation loss, refractive index (derived), and visibility.

- Observation sites (buoys) required:

- (a) 305 DO at 600 n mi except for 44 of these which are at 200 n mi spacing (space vehicle recovery areas)

- 12 CNA at 150 n mi spacing

- 317 Total requirements

- (b) 293 of the 317 occur at USAF sites supporting 1 USAF activity
(281 DO and 12 CNA)

- 12 of the 317 occur at (DO) sites supporting 2 USAF activities

- (c) 305 Different observation sites (buoys) for USAF requirements

D. U.S. Coast Guard (USCG)

- Six parameters added:

- Ambient light, atmospheric electricity, dew point, insolation, precipitation rate, and transparency.

- Five changes in characteristics (all conforming to "system" values):

- (a) Vertical layer: "surface (top of buoy mast)-5000 m depth."

- (b) Vertical sampling intensity: "20 LAPSO levels plus an observation within 50 m of bottom to maximum depth of 5000 m."

- (c) Duration of observation: "10 minute average."

- (d) Synchronization of observations: "10 minutes and 1 minute."

(e) Horizontal spacing clarified for Ice Patrol 10 x 50, 30 x 50 and 100 x 100 n mi spacing.

- System applicability:

- (a) Nineteen, all "system" parameters except ambient noise, fully met—with the exception of the fine scale spacing such as in Ice Patrol, Search and Rescue and Oceanographic Services.

- (b) Ten parameters not met: Upper-air profiles of temperature, humidity and wind, bathymetry, chlorophyl, nutrients, oxygen, pH, pictures of marine life, and plankton hauls.

- Observation sites required:^{*}

- (a) 155 DO 5 OSVs, 150 at 25 to 100 n mi spacing, plus some variable number for Oceanographic Services (200 sites).

- 519 CNA 1 OSV, 518 at 10 to 100 n mi spacing plus an unknown number for Search and Rescue.

- 674 Total plus some variable and unknown number.

- (b) 612 of the 674 occur at USCG sites supporting 1 USCG activity

- (143 DO and 469 CNA)

- 31 of the 674 occur at USCG sites supporting 2 USCG activities

- (6 DO and 25 CNA)

- (c) 643 Different observation sites for USCG requirements

- (plus an unknown number for Ocean Svcs and S & R).

E. U.S. Navy (USN)

- Parameters added: none
- Three changes in characteristics (all conforming to "system" values):

- (a) Vertical layer: "surface (top of buoy mast)—5000 m depth."

- (b) Vertical sampling intensity: "20 IAPSO levels to 5000 m."

*The U.S. Coast Guard has operational requirements for observations at 674 sites, 297 associated with the International Ice Patrol and 227 connected with 13 standard sections. Ice Patrol observations are required bi-weekly during February through June. Standard section observations are required only monthly. These requirements can best be met by observational platforms other than synoptically reporting unmanned moored data buoys. There are, however, some additional requirements for monitoring the Ice Patrol region and the standard sections on a synoptic basis. This could be accomplished by spacing three buoys along each of the standard sections and using a small, densely spaced grid of seven data buoys on the eastern slope of the Grand Banks near 44.5° N, 48.5° W.

(c) Synchronization of observations: "10 minutes and 1 minute."

A number of items for surveys and ranges which had previously caused some misunderstanding were clarified.

• System applicability:

(a) Twenty "system" parameters fully met—with the exception of fine scale support to test ranges which, with minor "system" changes could be met.

(b) Thirteen upper air parameters for airborne support not met: Atmospheric electricity, clouds (amount, base, and tops), cosmic radiation, humidity, ice particle distribution, ozone, refractive index, temperature, vertical motion, visibility, and wind.

(c) Twelve other parameters not met: Bathymetry (in test ranges), biological sampling, bottom sampling, cloud cover, gravity, magnetic field, nutrients, pictures of bottom, propagation loss, sea state, sediment deposit and tidal fluctuation.

• Observation sites (buoys) required:

(a) 531 DO at 600 n mi spacing except for 9 at 10 to 20 n mi spacing in test ranges.

18 CNA at 10 to 50 n mi spacing in test ranges

549 Total requirements

(b) 18 of the 549 occur at USN sites supporting 1 USN activity (2 DO and 16 CNA)

262 of the 540 occur at USN sites supporting 2 USN activities

(261 DO and 1 CNA)

2 of the 549 occur at DO sites supporting 3 and 4 activities respectively (268 DO and 18 CNA requirements)

— this equals approximately

(c) 282 Different observation sites (buoys) for USN requirements

During the 1968 refinement effort, a near-shore and estuarine region has been more clearly defined (and accepted). The near-shore, estuarine and Great Lakes

regions represent sources of data requirements (and data users) that have not been completely investigated. The needs of FWPCA are well defined but comparable requirements for other activities, that probably warrant more careful study, include various forms of recreational boating and fishing, public health, Coast Guard interests within 25 mi of the coast, test ranges, and the exploitation of natural resources. The FWPCA data requirements, given below, are probably representative of other agency (user) data requirements that may be established in the future.

F. Federal Water Pollution Control Administration (FWPCA)

- Five parameters added: Air temperature, insolation, ambient light, transparency and turbidity.
- One change in characteristics (conforming to the "system" value): Frequency of observations: "three hours." Areas of data interest, x, y and z sampling intensities were clarified.
- System applicability: Tentatively proposed system sensing capabilities were oriented toward DO and CNA (> 25 n mi from coast) operations and not toward FWPCA activity at this time. The biggest problems are x, y, z and t sampling intensities. Many problems are different. These requirements should be studied next year.
- Observation sites (buoys) required:
 - (a) 200 at 20 n mi spacing in the Great Lakes.
 - (b) 600 (estimated) at 1-10 n mi spacing in pertinent estuaries (200) and near-shore waters (1 line of buoys 10 n mi spacing along 4000 n mi coast line = 400).
 - (c) 800 different observation sites (buoys) estimated for FWPCA requirements.

The task for estimating the number of buoys required for FWPCA is very difficult and requires additional information. The number of estuaries and the number of data locations required in each estuary (and in the near-shore waters) have not yet been established. Each estuary will probably have to be treated on an individual basis, with data location requirements possibly established by experiment. However, what is

important is that with an estimate of 100 estuaries, and an average of 2 buoys each, plus the 400 for one line of buoys 10 n mi off the coast and 10 n mi apart, plus the 200 for the Great Lakes, a total of 800 buoys is probably a conservative estimate for satisfying the data requirements of FWPCA. If this estimate is even approximately correct, the large number of required near-shore, estuarine, and Great Lakes buoys, as compared with buoys needed for other operational requirements, it is significant and implies the necessity to investigate the cost-effectiveness aspects of alternative platforms, such as fixed towers and unmanned data buoys.

4.2.2 Summary of Refined Operational Data Requirements

The results of the analysis of the agencies' refined operational data requirements can be expressed in terms of: (a) parameters required, (b) applicability of tentatively proposed "system" sensing characteristics, and (c) observation sites (buoys) required. The desired characteristics of measurements of the refined operational data requirements are very similar to the proposed "system" values but are too voluminous to present here. They are listed in the assessment sheets in Appendix IV.

4.2.2.1 Required Parameters

The summary of the parameters required by the DO and CNA operational activities of the agencies plus those for FWPCA for Near Shore estuaries and the Great Lakes are given in Table 4-1. For convenience, this table is divided into parts A and B. The twenty tentatively proposed "system" parameters are listed in part A. Part B contains the required "grey area" parameters and those "beyond the 5-yr buoy SOA." The entries in the table are coded to indicate when the statement of requirement for that particular parameter was made. An entry of "I" means that the parameter was initially requested by the agency in 1967, while an "A" indicates that the parameter requirement was added during the 1968 refinement process. As indicated in Table 4-1 part A, ESSA, USAF, and USCG made ten additions of meteorological and nine of oceanographic tentative "system" parameters, while FWPCA added two of each. Air Force and Navy indicated refined requirements for all 20 "system" parameters, for at least some operation, and Coast Guard required all but ambient noise. ESSA indicated a need for 15 of the parameters listed; BCF needed only eight.

TABLE 4-1
PARAMETERS REQUIRED BY AGENCIES FOR
OPERATIONAL ACTIVITIES
(Refined Requirements)

(a) "System" Parameters

Parameters	BCY	ESSA	USAF	USCG	USN	FWRCA
<u>Meteorological</u>						
Air temperature	I	I	I	I	I	A
Atmospheric electricity			A	A		
Atmospheric pressure		A	I	I		
Dew point		A	A	A		
Insolation			A	A		A
Precipitation rate	I	A	A	A		
Wind direction	I	I	I	I		
Wind speed	I	I	I	I		
<u>Oceanographic</u>						
Ambient light						
Current direction	I	I	A	A	I	A
Current speed			I	I		
Salinity	I	I	A	A	I	I
Sound speed			A	A		
Transparency	I	A	A	A		A
Water pressure			A	I		
Water temperature	I	I	I	I	I	
Wave direction			I	I		
Wave height			I	I		
Wave period			I	I		

23 Additions

(b) "Grey Area" and "Beyond Sat Buoy SOA" Parameters

Parameters	BCY	ESSA	USAF	USCG	USN	FWRCA
<u>Grey Area</u>						
Bathymetry					I	
Bottom photographs					I	
Elect. vol. conductivity			Delete			A
Gravity			Delete			
Magnetic field intensity						
Magnetic field direction						
Oxygen						
pH						
Propagation loss						
Radiological chemicals						
Sea state					I	
Sediment deposit						
Tidal fluctuation			Delete			
Total cloud amount						
Turbidity						
Pictures of fish						
Visibility						
<u>Beyond Sat Buoy SOA</u>						
Air density						
Atmos. electricity (u/a)						
Biological parameters						
Bottom sampling						
Chemical parameters						
Chlorophyl						
Cloud base						
Cloud top						
Cosmic radiation						
Ice crystal size						
Nutrients						
Ozone content						
Plankton						
Rawinsonde (T, P, RH, V)	I (2 hrs)	I	I	I	I	I
Refractive index						
Vertical motion (u/a)						

3 Additions

3 Deletions

Specific parameters required by all responding agencies include air temperature, wind velocity, current velocity, salinity, and water temperature. Atmospheric pressure, dew point, precipitation rate, sound speed, transparency, water pressure, and wave measurements are needed by four of the five agencies with DO and CNA activities.* Insolation and ambient light are wanted by two thirds of all agencies.

This leaves atmospheric electricity required only by USAF, USCG, and USN; ambient noise is needed only by USN on an ocean-wide basis, and by USAF in a limited region in the northeastern part of the Gulf of Mexico in support of the Eglin AFB test range. Thus, with some exceptions, the proposed 20 "system" parameters and measurement characteristics generally meet a large part of the stated operational data requirements of these agencies.

In Part B of Table 4-1, there are corresponding entries of "I" and "A" for the "grey area" and "beyond-the-5-yr-SOA" parameters, but it should be noted that there were only three additions of parameters here during refinement as compared to the 23 additions of "system" parameters. In fact, ESSA deleted their 1967 stated operational requirement for tidal fluctuation and magnetic field intensity and direction. Navy had stated requirements for 22 non-"system" parameters; USCG is next, stating a need for eight of them. Air Force and FWPCA need only five non-"system" parameters and both BCF and ESSA need only upper air sounding data.

Rawinsonde data, which represent upper air profiles of humidity, temperature, and wind plus the potential of other computable values, are required by all the agencies with DO and CNA operations. Of all the other parameters, there are only eight that are required even by two agencies (namely, biological parameters, cloud amount, nutrients, oxygen, pH, propagation loss, refractive index, and visibility). Since there are limited requirements for some of the parameters in Table 4-1 Part B, and some may be better measured by other existing or potential platform capabilities, further investigation into these requirements and the need for estimates of their relative values or priorities is indicated.

These refined operational data requirements can be separated into the data needs for the Deep Ocean region and those for the Coastal North American region and, within

* FWPCA is restricted to near-shore waters.

these regions, those requirements with global or general coverage and those limited areas only can be delineated. In addition, although they are stated data requirements, the parameters required by only one agency could be set aside temporarily and only parameters required by two or more agencies considered for an initial summary of "system" requirements. (This assumes that all requirements are of equal importance and that commonality of need is justification for including a parameter.) Although not all important system aspects have been considered, commonality of data requirements does provide a rational framework for delineation of possible initial DO and CNA "system" sensing characteristics.* Table 4-2 presents this information.

4.2.2.2 Applicability of the Tentatively Proposed "System."

The applicability of the tentatively proposed "system" sensing characteristics to the refined stated data requirements of the operational DO and CNA activities of the

TABLE 4-2
PARAMETERS COMMONLY REQUIRED FOR DO AND CNA BY
OPERATIONAL ACTIVITIES
(Refined Requirements)

Parameters	DO	CNA
Proposed "System"	ALL 20	<u>General</u> 15 of 20 are required for the CNA region* <u>Limited Areas</u> 19 of 20 are required for continental shelf area; the 20th (ambient noise) is required for the NE Gulf of Mexico
Grey Area	<u>Global</u> Total cloud amount <u>Limited Areas</u> Bathymetry	<u>General</u> <u>Limited Areas</u> Bathymetry
> 5-yr SOA	<u>Global</u> Upper-air temperature, pressure, humidity and wind, refractive index, visibility <u>Limited Areas</u> Nutrients	<u>General</u> Upper-air temperature, pressure, humidity and wind <u>Limited Areas</u>

*Atmospheric, electricity, insolation, ambient light, ambient noise, and transparency not required.

*Relative values of parameters, observational layers, relative worth of missions, cost effectiveness, and development feasibility are among other important systems aspects which should also be considered.

five agencies can be expressed in terms of the number of requirements fully met, and those not met and why. These points are summarized in Table 4-3.

4.2.2.3 Number of Observation Sites (Buoys) Required

Once refined agency data requirements for observations at various ocean locations have been collected and analyzed, it is possible to determine first the number of observation sites required to satisfy each agency's requirements, taking into account the redundancy (or commonality) of that agency's requirements at some of the sites.

Second, all of the sites required by all the agencies can be analyzed for commonality of requirements at some sites. Then the minimum number of observation sites needed to satisfy all agencies' operational data requirements can be determined. Table 4-4, discussed in detail in the next paragraph, delineates the individual agency buoy systems

TABLE 4-3
"SYSTEM" APPLICABILITY TO REFINED OPERATIONAL DATA REQUIREMENTS

Agency	Fully met		Not met	Why not met
	Meteoro-logical	Oceano-graphic		
BCF	3	5	2 Oceanographic 1 Upper-Air	Fine x, y scale in limited CNA area. > 5-yr buoy SOA
ESSA	6	9	5 Upper-Air	> 5-yr buoy SOA
USAF/AWS	8	12	1 Meteorological 9 Upper-Air	"Grey Area" > 5-yr buoy SOA
USCG	8	12	19 "System" 2 Oceanographic 5 Oceanographic 5 Upper-Air	Fine spacing in limited DO & CNA areas "Grey Area" > 5-yr buoy SOA > 5-yr buoy SOA
USN	8	12	14 "System" 8 Oceanographic & 1 Meteorological 3 Oceanographic 13 Upper-Air	Fine spacing in limited DO & CNA test range areas "Grey Area" > 5-yr buoy SOA > 5-yr buoy SOA

(total observation sites required) needed to meet the refined operational requirements of each agency. There is, of course, some redundancy remaining because these agency buoy systems, if deployed, would overlap each other in some regions. This redundancy represents the commonality among requirements of different agencies. Table 4-5 summarizes the total number of required observation sites made up of "system" (NDBS) and non-"system" sites that would satisfy, without redundancy, all the combined individual agency data requirements of Table 4-4. In addition, Table 4-5 delineates the distribution of total national data requirements at the required observation sites and demonstrates the applicability of a DO network of buoys with a spacing of approximately 600 naut. mi and a CNA network with a variable (100 to 150 naut. mi) spacing. Such networks have been considered by agency representatives as acceptable for an initial NDBS.

TABLE 4-4
NUMBER OF OBSERVATION SITES (BUOYS) REQUIRED FOR REFINED AGENCY OPERATIONAL DATA REQUIREMENTS

	Total* requirements for obs at sites	Deep Ocean					Coastal North America				
		Distribution of requirements at obs. sites				Total sites required (buoys)	Total* requirements for obs at sites	Distribution of requirements at obs. sites			
		1 Rqt	2 Rqts	3 Rqts	4 Rqt			1 Rqt	2 Rqts	3 Rqts	4 Rqt
BCF	110	48	31	0	0	79	290	80	105	0	0
ESSA	261	261	0	0	0	261	279	279	0	0	0
USAF	305	281	12	0	0	293	12	12	0	0	0
USCG	155	143	6	0	0	149	519	489	25	0	0
USN	531	2	261	1	1	265	18	16	1	0	0
Totals	1362	735	310	1	1	1047	1118	856	131	0	0
											987

*Common use of an observation site for more than one set (AMO) of data requirements has been considered in this column.

TABLE 4-5
NUMBER OF OBSERVATION SITES (BUOYS) REQUIRED FOR REFINED NATIONAL OPERATIONAL DATA REQUIREMENTS

	Total* requirements for obs at sites	Distribution of requirements at "system" sites						Required "system" sites (buoys)	Distribution of requirements at non—"system" sites			Required non—"system" sites (buoys)	Total required no. of sites (buoys)
		1 Rqt	2 Rqts	3 Rqts	4 Rqts	5 Rqts	>2 Rqts		1 Rqt	2 Rqts	>2 Rqts		
DO	1362	0	0	0	172	46	43	261	165	8	0	173	434
CNA	1118	93	77	100	8	1	0	279	482	26	0	508	787
Totals	2480	93	77	100	180	47	43	540	647	34	0	681	1221

*Common use of an observation site for more than one set (AMO) of data requirements has not been considered in this column.

Each agency's total data requirements for observations at sites are separated into two categories in Table 4-4: those in DO and those in CNA. These total requirements are the sum for each AMO of all requirements for observations at sites without regard to whether some sites from one AMO could be common with those of another AMO. In the next four columns under both the DO and CNA regions, the distribution of these total requirements at required observation sites is presented by indicating the number of sites accommodating one, two, three, or four requirements at each site. Thus, for each agency, the sum of the number of observation sites multiplied by the number of requirements supported at each site equals the total requirements for observation sites. The sum of the number of observation sites supporting single or multiple requirements equals the total number of observation sites (buoys) required to meet each agency's total requirements. The total sites required (in the last columns under both DO and CNA regions) takes into account the amount of commonality at observation sites that exists among the various AMOs of each agency. For example, the 110 total DO requirements for BCF are distributed as 48 requirements at sites supporting only one BCF requirement and 62 requirements at 31 sites each supporting two BCF requirements. These 48 single and 31 double requirement observation sites equal 79 DO observation sites (buoys) that meet all 110 BCF requirements.

At the bottom of Table 4-4, the numbers in each of these columns are totaled. Thus, there are 1362 total DO requirements for the five agencies individually. These requirements can be satisfied by only 1047 observational sites because some would be supporting the requirements of more than one agency. Of these 1047 DO observation sites, 735 sites support one set of data requirements each, while 310 sites support two requirements. There would be one site supporting three Navy requirements and one supporting four Navy requirements.

The NDBS, however, must be structured on the basis of commonality among agencies, not just within agencies. Therefore, although Table 4-4 represents the summary of the required number of buoys to support the operational activities of each agency, a smaller number of buoys will be required to meet the combined or national data requirements. This is developed in Table 4-5, which also begins with the total number of observations at sites (1362 DO and 1118 CNA) by all agencies to meet the

data requirements of each AMO considered individually (i. e., with no commonality among AMOs considered). In the next few columns, the distribution of these requirements is given for tentatively proposed "system" observation sites and for non-"system" observation sites. The number of "system" sites has been summed to indicate the total number of "system" sites; the total number of non—"system" observation sites is also given. These are combined in the final column and they equal the total number of required observation sites or buoy locations, namely 434 sites required in DO and 787 sites required in CNA. Table 4-4 shows that if the five agencies implemented individual data buoy systems to meet each agency's operational data requirements, the five agencies would instrument 2034 (1047 + 987) buoys to satisfy 2480 (1362 + 1118) total requirements for observations at sites. However, by combining all five agencies' operational data requirements, the same task can be accomplished by a single combined system with buoys at only 1221 (434 + 787) sites. Thus, a reduction of about 40 percent would be achieved by serving the five agencies with a single combined DO and CNA operational data buoy system.

In Section 4.1, the rationale for the 600-n mi grid DO network and the 100 to 150 n mi grid CNA network was presented in detail. These two networks, while not satisfying all requirements, would cover with a total of 540 buoys, the ocean areas in which requirements for operational observations exist. Buoys would have to be placed at 681 additional sites to meet the remainder of the location requirements. However, Table 4-5 indicates that the 540 buoys in the tentatively proposed DO and CNA "system" networks are located primarily at points that each have numerous common requirements. For example, 370 of the 540 buoys satisfy three or more observational site requirements, and 77 satisfy two site requirements, leaving only 93 that satisfy only one site requirement. In fact, the 540 buoys satisfy 1765 of the total 2480 requirements for observations at sites, leaving unsatisfied only 715 of the total requirements; i. e., more than two-thirds of the total requirements for observations at sites are satisfied by the "system" CNA and DO networks.

Table 4-5 shows that there are 681 non—"system" sites needed to satisfy the remaining 715 observations data requirements, because the majority of these sites satisfy only a single observational requirement. USCG Ice Patrol, Standard Sections,

and Ocean Service account for nearly 600 of the non-"system" site requirements.

More will be said about this in later sections.

4.2.2.4 Requirements by Modular Deployment Zones

The Deep Ocean and the Coastal North American regions, which have nearly equal numbers of required buoys (~ 261 vs. 279 in proposed "system" networks, can be broken up into modular deployment zones (MDZs). These zones would represent areas within which the data requirements and the benefits obtained from the data might be relatively homogeneous. The number of "system" buoys per zone would be essentially equal and the buoys could be deployed in any desired stepwise fashion, zone by zone. One suggested breakdown into MDZs is presented in Fig. 4-3. The names and initials of these various MDZs and the required number of tentatively proposed "system" network buoys for each zone are indicated in Table 4-6.

These modular deployment zones are primarily of interest for delineating the deployment problem and studying various deployment methods and capabilities as a basis for system trade-offs. Relating the refined operational data requirements of the agencies to these same MDZ categories provides a basis for more detailed analysis. Table 4-7 shows those agencies that have data requirements in each MDZ. The numbered entries show the requirements of each agency without consideration for the potential redundancy of common observation sites among the different agencies. The entries, indicating each agency's needs in a given DO or CNA MDZ, indicate in the first column under the agency the required number of data observation sites (or buoys) that fall in the tentatively proposed "system" networks which are spaced 600 naut. mi. in DO and 100 to 150 naut. mi. in CNA. The number of non-"system" data observation sites that are required on too fine a scale for the "system" network are entered in the second column under the agency. The number of required "system" sites (or buoys) per MDZ by an agency, as compared with the total number required by the "system" network to cover that MDZ, as indicated in Table 4-6, is an indication of the percentage coverage required for that zone by the agency. For example, if only 4 "system" network buoys are required by an agency in a given zone which has 40 "system" network buoys assigned to it that agency's data requirements in that zone call for very limited coverage. Of course, the agency may have many non-network buoys

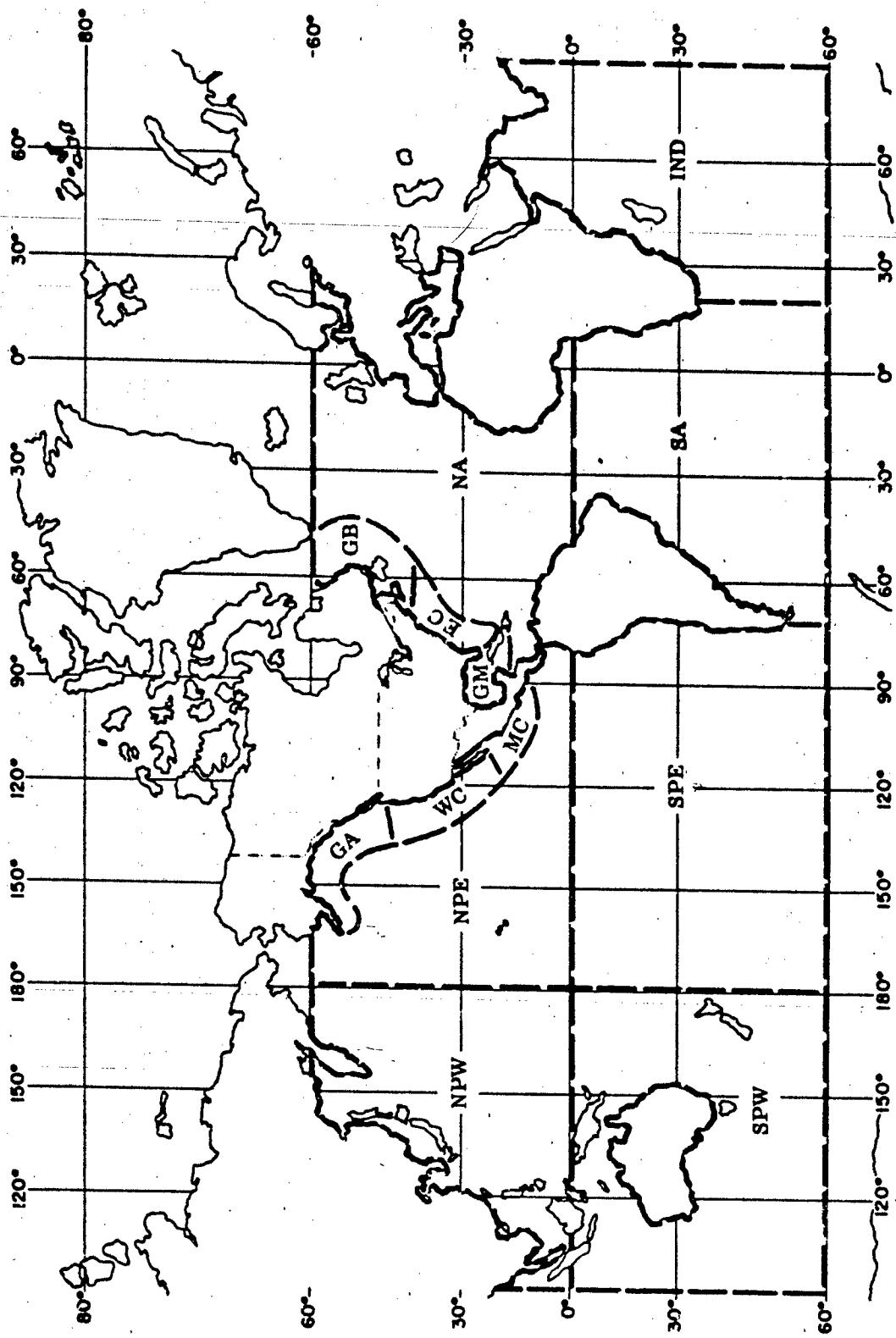


Fig. 4-3. Tentatively proposed modular deployment zones (13)

required in that zone also, but these are probably restricted to a limited portion of the zone and are often concentrated in a very fine-scale spacing and thus have little to do with coverage of the entire zone. It should be noted that only ESSA has an operational requirement for data from every one of the 13 zones and that coverage is complete or equivalent to the entire tentatively proposed buoy "system" network in each zone. Air Force and Navy also have complete "system" network coverage requirements in the Deep Ocean, but stated a need for only a few locations in CNA for support of test ranges. The operational requirements for BCF are limited at this time to the Pacific Ocean. However, if and when their applied research for corresponding problems in the Gulf of Mexico and the Atlantic ocean produces operational procedures, BCF may well become an agency with more widespread requirements, probably in all the MDZs.

TABLE 4-6
PROPOSED MODULAR DEPLOYMENT ZONES AND "SYSTEM" SITES

Deep Ocean		Coastal N. America	
Name	Number of "System" Observation Sites (buoys)	Name	Number of "System" Observation Sites (buoys)
N. Atlantic (NA)	38	Grand Banks (GB)	43
N. Pacific East (NPE)	36	East Coast (U.S.) (EC)	47
N. Pacific West (NPW)	35	Gulf of Mexico (GM)	54
S. Atlantic (SA)	33	Mexican Coast (West) (MC)	36
S. Pacific East (SPE)	49	West Coast (U.S.) (WC)	51
S. Pacific West (SPW)	35	Gulf of Alaska (GA)	48
Indian Ocean* (IND)	35		
Total	261	Total	279

*Mostly in Southern Hemisphere

As indicated directly above in Section 4.2.2.3, most agencies have very few requirements for non-"system" network buoy locations. This is delineated further by MDZs in Table 4-7. BCF has a total of 50 in the West Coast MDZ to sense the small-scale features near the U.S. coast while, with the exception of U.S. Coast Guard, the rest of the agencies have few (or no) similar requirements. On the other hand, Coast

TABLE 4-7
REFINED AGENCY OPERATIONAL DATA REQUIREMENTS FOR TOTAL REQUIRED SITES BY MDZ*

MDZ	BCF "System" sites	Non- "System" sites	Agency						Total requirements
			ESSA "System" sites	ESSA "System" sites	USAF "System" sites	USAF "System" sites	USCG "System" sites	USN "System" sites	
<u>Deep Ocean</u>									
NA	0	0	38	0	38	7	4	78	2
NPE	36	0	36	0	36	12	5	47	36
NPW	9	0	35	0	35	3	1	14	35
SA	0	0	33	0	33	2	0	0	33
SPE	29	0	49	0	49	8	0	0	49
SPW	5	0	35	0	35	0	0	0	35
IND	0	0	35	0	35	0	0	0	35
Total**	79	0	261	0	261	32	10	139	261
<u>Coastal North America</u>									
CB	0	0	43	0	0	0	18	255	0
EC	0	0	47	0	0	0	16	91	1
GM	0	0	54	0	9	3	9	45	0
MC	36	0	36	0	0	0	0	0	0
WC	51	50	51	0	0	0	6	54	3
GA	48	0	48	0	0	0	0	0	0
Total**	135	50	279	0	9	3	19	445	4
								13	476
									511

* Common use of an observation site (network or non-network) for more than one agency's data requirements has not been considered in this table.

**See Table 4-4.

Guard has nearly 10 times more requirements for non-"system" sites than it has for "system" sites. The distribution by MDZs of USCG requirements for non-"system" network locations is delineated in Table 4-7, with 255 of the total 445 located in the Grand Banks MDZ to support requirements for Ice Patrol and Standard Sections.*

In Table 4-7, last two columns on the right, titled "Total Requirements," show the sum of all agency requirements in each MDZ for "system" network sites and for non—"system" observation sites. These are the total of all observation sites required by each agency, assuming each had its own data buoy network. Thus, observation site requirement redundancy among the several AMOs of a given agency has been considered and eliminated, but the corresponding redundancy among the various agencies for observation sites has not been eliminated. Thus, if all five agencies had individual data buoy systems, 872 Deep Ocean observation sites would be required, at "system" spacing (600 n mi), 476 CNA observation sites would be required, with 100 to 150 n mi spacing, and 175 DO and 511 CNA non—"system" sites (a total of 2034) would be required to meet all the refined operational data requirements of the five agencies. However, by choosing observation sites that can serve several agencies in common, as in a truly national (or combined) data buoy system, considerably fewer buoys (1221) would be required for the operational requirements as shown in Table 4-5. The details of such a combined system are presented by MDZs in Table 4-8. This table shows, in part A, the tentatively proposed "system" network sites and, in part B, the non—"system" sites; each part in turn is divided into the MDZs of the Deep Ocean and Coastal North American regions. In the first column after the names of the MDZs in each part of the table, the total requirements for individual observation sites, for all AMOs for all agencies, is given without consideration of potential redundancy at common observation sites. Thus, the total data requirements for "system" observation sites (1181 DO and 584 CNA) plus those for non—"system" observation sites (181 DO and 534 CNA) is 2480 in Table 4-8; it is the same as the total individual AMO data requirements (2480) for observation sites for DO (1362) and CNA (1118) in Tables 4-4 and 4-5. In Table 4-8, as was done in Table 4-4, other columns show the distribution of these total requirements at required observation sites along with the numbers of requirements accommodated. These data are given by MDZs rather than as totals for DO and CNA. In the final column in each part of Table 4-8, the minimum total

*Most of these USCG requirements are for monthly or bi-weekly observations. See footnote, page 43.

number (after site redundancy has been eliminated) of required observation sites (or buoys) in each MDZ is shown for a combined or national system. The total of 540 "system" sites (261 DO and 279 CNA) plus 681 non-"system" sites (173 DO and 508 CNA) gives 1221 required sites to meet the total requirements for observations at sites (2480) of all agencies; it is the same as the 434 DO and 787 CNA that give 1221 required sites in Table 4-5. Parts A and B of Table 4-8 delineate by MDZs the results of an analysis of the distribution of total data requirements at observation sites for combined data collection from tentatively proposed "system" networks and non-"system" sites. These results demonstrate that even at the level of thirteen MDZs, as compared to the previous results at two regions (DO and CNA), the number of sets of data requirements satisfied by "system" observation sites is generally quite significant. Only Grand Banks, East Coast, Gulf of Mexico, and Gulf of Alaska MDZs do not, on the average, have at least three or more requirements per site. However, at non-"system" sites, all or the great majority of observation sites in each MDZ support the data requirements of only a single operational activity. This detailed analysis by MDZs demonstrates that the 540 "system" sites (or buoys) would satisfy 1765 of the total 2480 requirements for observational data. The results of this analysis of the distribution of data requirements at observation sites in MDZs is anticipated to be of value to buoy deployment planning.

4.2.2.5 Parameter Requirements and Locations in MDZs

Table 4-8 shows the breakdown of the DO and CNA national data requirements into thirteen proposed MDZs including the number of "system" network sites and non-"system" sites required in each MDZ. This might be used to make estimates of relative utility of data buoys in one zone as compared to another. However, it gives no inkling of whether some parameters are more important than others in some zones. To document this aspect of the refined data requirements, the total number of individual AMO requirements for observation of each of the parameters required for operational activities was listed with the total number of required data locations (sites) to which these would reduce if commonality were considered. The number of required locations for each parameter was categorized further by the required number of "system" network and non-"system" locations and how many of the data locations had

TABLE 4-5
**REQUIRED NUMBER OF OBSERVATION SITES (BUOYS) BY MDZ FOR REFINED
 NATIONAL OPERATIONAL DATA REQUIREMENTS**

A. "System" Network Sites

MDZ	Total* rqts for obs at sites	Deep Ocean							Total sites req'd (buoys)	MDZ	Coastal North America							Total sites req'd (buoys)			
		Distribution of requirements at observation sites										Distribution of requirements at observation sites									
		4 Rqts	5 Rqts	6 Rqts	7 Rqts	8 Rqts	9 Rqts				1 Rqt	2 Rqts	3 Rqts	4 Rqts	5 Rqts						
NA	160	30	6	0	0	0	0	38	GB	61	25	18	0	0	0	43					
NPE	207	0	14	19	2	0	1	36	EC	66	30	15	2	0	0	47					
NPW	152	24	10	1	0	0	0	35	GM	72	38	14	2	0	0	54					
SA	132	33	0	0	0	0	0	33	MC	108	0	0	36	0	0	36					
SPE	245	20	9	20	0	0	0	49	WC	163	0	0	42	8	1	51					
SPW	145	30	5	0	0	0	0	35	GA	114	0	30	18	0	0	48					
IND	140	35	0	0	0	0	0	35													
Totals	1181	172	46	40	2	0	1	261**	Totals	584	93	77	100	8	1	279**					

*Common use of an observation site for more than one set (AMO) of data requirements has not been considered in this column.

**See Table 4-5.

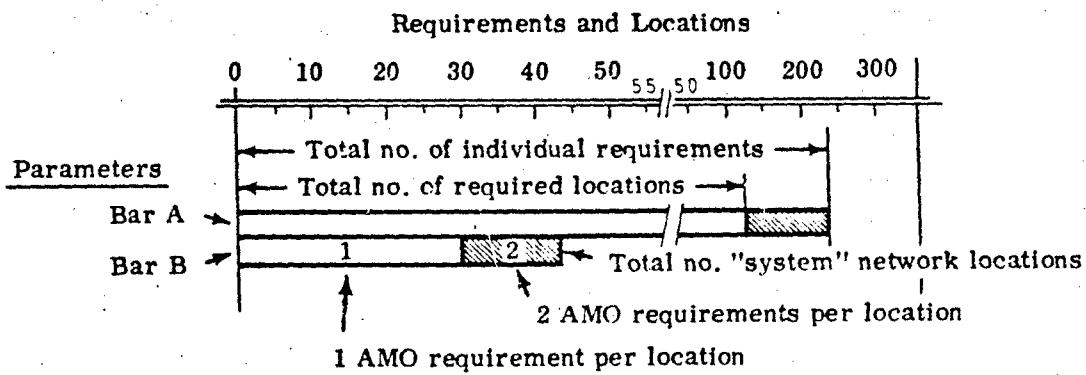
B. Non-"system" sites

MDZ	Total* rqts for obs at sites	Deep Ocean			Total sites req'd (buoys)	MDZ	Total* rqts for obs at sites	Coastal North America			Total sites req'd (buoys)				
		Distribution of requirements at observation sites						Distribution of requirements at observation sites							
		1 Rqt	2 Rqts	> 2 Rqts				1 Rqt	2 Rqts	> 2 Rqts					
NA	91	83	4	0	87	GB	268	242	13	0	255				
NPE	63	55	4	0	59	EC	103	83	10	0	93				
NPW	17	17	0	0	17	GM	48	46	1	0	47				
SA	2	2	0	0	2	MC	0	0	0	0	0				
SPE	8	8	0	0	8	WC	115	111	2	0	113				
SPW	0	0	0	0	0	GA	0	0	0	0	0				
IND	0	0	0	0	0										
Totals	181	165	8	0	173**	Totals	534	482	26	0	508**				

*Common use of an observation site for more than one set (AMO) of data requirements has not been considered in this column.

**See Table 4-5.

requirements from 1, 2, 3, or more than 3 activities. To make these numbers of parameter requirements and data locations more meaningful, and to provide one measure of the relative importance of the various parameters in the different MDZs, bar graphs of these numbers of parameter requirements and required data locations were prepared. The parameters on these bar graphs are separated into groups of "system," "grey area," and "beyond the 5-yr buoy SOA" so that relevant comparison can be made. This information is presented for each MDZ in the following simplified bar graph plotting model.



Bar graph plotting model.

The full length of Bar A represents the total number of independent, or individual, requirements for that parameter regardless of whether several may be for similar locations. This full length minus the hatched portion (number of requirements in excess of one at common locations) leaves the unhatched portion of Bar A which represents the total number of separate locations required to meet the total requirements when commonality is combined at each location where possible. Directly beneath Bar A, the full length of Bar B indicates the total number of the tentatively proposed "system" buoy network locations involved in the total number of required locations. Of course, the difference between Bar A and Bar B then is the number of required non-"system" locations. Bar B, representing required "system" network locations, is further divided by cross hatching. The numeral in each portion of the bar indicates

the number of different AMO requirements for that parameter at each of those "system" network locations. For example, a "3" in the clear portion of Bar B that extends to "30" on the scale, indicates that each of 30 "system" network locations has three different AMO requirements for that parameter. If the hatched area extends on to 45 and has a number 4 in it, this means 15 more network locations in that zone have 4 common AMO requirements for that parameter at each of those locations. All this information on the number of parameter requirements and data locations is presented with two pages of bar graphs for each MDZ in Table 4-9 (A through M).

4.2.2.6 Tentative Observation Sites in MDZs

The summary of the analysis of operational data requirements has indicated the important qualities or properties of these refined requirements with the exception of the exact sites or locations from which specific data are required. In most cases, the data locations are arbitrary or a matter for interpretation. Very few agencies have activities that require data from a precise geographical location; rather, most agencies require areas of the ocean to be sampled from a specified mesh or grid spacing which can be made to coincide with certain specific locations such as those required by test ranges. Agencies submitted only a few chart displays with requirements that specified exact locations from which the agency wanted data collected. Thus, the charts included in this report, showing tentatively proposed data observation sites, are the result of the analysis and TRC's interpretation of the agencies' statements of refined operational data requirements. For the convenience of handling and communicating the desired information, and for support to system deployment trade-off studies, those locations from which it is understood data will likely be required are treated as sites for data observations (buoys) in each of the thirteen MDZs. The charts, which are presented as Fig. 4-4 (A through M), indicate the "system" network observation sites, the non—"system" observation sites, and the numbers of sites of each type. In addition, distinction is made between those observation sites, both "system" and non—"system," that support only one requirement and those that support multiple requirements. In some MDZs (e.g., East Coast), the majority of the sites support only one requirement while, in others (e.g., North Atlantic), every observation site supports the requirements of at least four different AMOs (in the N. Atlantic, the requirements are from three different agencies).

TABLE 4-9A
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(GRAND BANKS MDZ: 43 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U	
	10	20	30	40	50	55	100	200	300	C	S	A	C	S	
										F	A	F	G	S	N
Ambient light															
Ambient noise															
Current velocity	1												x		
Salinity															
Sound speed	1														
Transparency													x		
Water press.	1												x	x	
Water temp.													x	x	
Wave meas.	1												x	x	
Air temp.													x	x	
Atmos. elect.	1													x	
Atmos. press.													x	x	
Dew point	1												x	x	
Insolation	1													x	
Precip. rate	1												x	x	
Wind velocity	1												x	x	

TABLE 4-9A (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(GRAND BANKS MDZ: 43 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	F
Bathymetry															x
Oxygen	1														x
Pictures of fish	1														x
"Beyond 5-yr SOA" parameters															
Chlorophyl															x
Nutrients	1														x
pH															x
Plankton	1														x
Rawinsonde	1											x	x		

TABLE 4-9B
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(EAST COAST (U. S.) MDZ: 47 Buoy "System" Network)

System parameters	Requirements and locations										B	E	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	S	S
	F	A	F	G	N										
Ambient light														x	
Ambient noise															
Current velocity											x	x	x		
Salinity	1										x	x			
Sound speed	1										x	x	x		
Transparency	1										x				
Water press.											x	x	x		
Water temp.	1										x	x	x		
Wave meas.	1										x	x			
Air temp.	1										x	x			
Atmos. elect.	1												x		
Atmos. press.	1										x	x			
Dew point	1										x	x			
Insolation	1											x			
Precip. rate	1										x	x			
Wind velocity	1										x	x			

TABLE 4-9B (Continued)
 REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
 (EAST COAST (U. S.) MDZ: 47 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U	
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	C	S
											F	A	F	G	C	S
Bathymetry																
Oxygen																
Sed. dep.																
Tidal fluct.																
Pictures of fish																
"Beyond 5-yr SOA"																
parameters																
Chlorophyl																
Nutrients																
pH																
Plankton																
Rawinsonde																

TABLE 4-9C
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(GULF OF MEXICO MDZ: 54 Buoy "System" Network)

System parameters	Requirements and locations								B	E	U	U	U	
	10	20	30	40	50	55	100	200	300	S	S	S	C	F
Ambient light											x	x		
	1	2												
Ambient noise											x			
	1													
Current velocity											x	x	x	
	1	2	3											
Salinity											x	x	x	
	1	2	3											
Sound speed											x	x	x	
		2	3											
Transparency											x	x		
	1	2												
Water press.											x	x	x	
	1	2	3											
Water temp.											x	x	x	
	1	2	3											
Wave meas.											x	x	x	
	1	2	3											
Air temp.											x	x	x	
	1	2	3											
Atmos. elect.											x	x		
	1	2												
Atmos. press.											x	x	x	
	1	2	3											
Dew point											x	x	x	
	1	2	3											
Insolation											x	x		
	1	2												
Precip. rate											x	x	x	
	1	2	3											
Wind velocity											x	x	x	
	1	2	3											

TABLE 4-9C (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(GULF OF MEXICO MDZ: 54 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	C	S
Bathymetry															x	
Oxygen															x	
Propag. loss														x		
Pictures of fish														x		
"Beyond 5-yr SOA" parameters																
Chlorophyl															x	
Nutrients														x		
pH														x		
Plankton														x		
Rawinsonde												x	x			
Refract. Index													x			
Visibility													x			

TABLE 4-9D
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(MEXICAN COAST MDZ: 36 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U	
	10	20	30	40	50	55	50	100	200	300	C	S	S	S	N
Ambient light															
Ambient noise															
Current velocity											x	x	x		
	>2														
Salinity											x	x	x		
	>2														
Sound speed											x	x	x		
	1														
Transparency											x				
	1														
Water press.											x	x	x		
	1														
Water temp.											x	x	x		
	>2														
Wave meas.											x	x	x		
	1														
Air temp.											x	x	x		
	>2														
Atmos. elect.															
Atmos. press.											x	x	x		
	1														
Dew point											x				
	1														
Insolation															
Precip. rate											x				
	1														
Wind velocity											x	x	x		
	2														

TABLE 4-9D (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(MEXICAN COAST MDZ: 36 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B C F	E S A F	U S A G	U S C G	U S N
	10	20	30	40	50	55	100	200	300						
"Beyond 5-yr SOA" parameters															
Constant press. hghts.													x		
Rawinsonde			1										x		

TABLE 4-9E
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(WEST COAST MDZ: 51 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U	
	10	20	30	40	50	55	50	100	200	300	C	S	A	C	S
										F	A	F	G	N	
Ambient light															
	1														
Ambient noise															
Current velocity															
Salinity															
Sound speed															
Transparency															
Water press.															
Water temp.															
Wave meas.															
Air temp.															
Atmos. elect.															
Atmos. press.															
Dew point															
Insolation															
Precip. rate															
Wind velocity															

TABLE 4-9E (Continued)
 Refined National Operational Parameter Requirements by MDZ
 (West Coast MDZ: 51 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	G
Bathymetry								■							x x
Total cloud amt.	1														x
Oxygen								□						x	
Sed. dep.	1														x
Tidal fluct.	1														x
"Beyond 5-yr SOA" parameters															
Bottom sampling		1													x
Constant press. htgs.							1					x			
Rawinsonde	1	2										x	x		

TABLE 4-9 F
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(GULF OF ALASKA MDZ: 48 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U
	10	20	30	40	50	55	100	200	300	C	S	S	C	S
Ambient light														
Ambient noise														
Current velocity											x	x	x	
	2		>2											
Salinity											x	x	x	
	2		>2											
Sound speed											x		x	
			1											
Transparency										x				
	1													
Water press.										x		x	x	
			1											
Water temp.										x	x	x	x	
	2		>2											
Wave meas.										x	x	x		
			1											
Air temp.										x	x	x		
	2		>2											
Atmos. elect.														
Atmos. press.										x	x			
			1											
Dew point										x				
			1											
Insolation														
Precip. rate										x				
			1											
Wind velocity										x	x	x		
	1	2												

TABLE 4-9 F (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(GULF OF ALASKA MDZ: 48 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	C	S
"Beyond 5-yr SOA" parameters															
Constant press. htgs.											x				
Rawinsonde	1										x				

TABLE 4-9G
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(NORTH ATLANTIC MDZ: 38 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U	
	10	20	30	40	50	55	100	200	300	C	S	S	A	C	
Ambient light															x x
	1														
Ambient noise															x
	1														
Current velocity															x x x x
	2														
Salinity															x x x x
	>2														
Sound speed															x x x
	2														
Transparency															x
	1														
Water press.															x x x
	2														
Water temp.															x x x x
	>2														
Wave meas.															x x x x
	>2														
Air temp.															x x x x
	>2														
Atmos. elect.															x
	1														
Atmos. press.															x x x x
	>2														
Dew point															x x x x
	>2														
Insolation															x x
	1														
Precip. rate															x x x
	1														
Wind velocity															x x x x
	>2														

TABLE 4-9G (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(NORTH ATLANTIC MDZ: 38 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B C F	E S A F	U S A G	U C G N
	10	20	30	40	50	55	50	100	200	300				
Bathymetry	1												x	
Total cloud amt.					2		>2						x	x
Oxygen	1												x	
Sed. dep.	1													x
Tidal fluct.					1		2							x
"Beyond 5-yr SOA"														
parameters														
Cld. base														x
	2													
Cld. tops														x
	1													
Plankton														x
	1													
Rawinsonde													x	x
	>2												x	x
Refract. ind.													x	x
	2				>2									
5 unusual U/A par.														
	1													x
Visibility													x	x
	2				>2									

TABLE 4-9H
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(NORTH PACIFIC EAST MDZ: 36 Buoy "System" Network)

System parameters	Requirements and locations								B	E	U	U	U	U	
	10	20	30	40	50	55	50	100	260	300	C	S	S	C	S
Ambient light															x x
	1		2 >2												
Ambient noise															x
	1														
Current velocity															x x x x x
	>2														
Salinity															x x x x x
	>2														
Sound speed															x x x
	2		2 >2												
Transparency															x
	1		2												
Water press.															x x x x
	2		>2												
Water temp.															x x x x x
	>2														
Wave meas.															x x x x x
	>2														
Air temp.															x x x x x
	>2														
Atmos. elect.															x
	1														
Atmos. press.															x x x x
	>2														
Dew point															x x x x
	>2														
Insolation															x
	1														
Precip. rate															x x x
	1		2												
Wind velocity															x x x x x
	>2														

TABLE 4-9H (Continued)
 REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
 (NORTH PACIFIC EAST MDZ: 36 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	C	G
											F	A	F	G	N
Bathymetry														x	x
Total cloud amt.													x	x	
Oxygen													x		
Sed. dep.														x	
Tidal fluct.													x		
"Beyond 5-yr SOA" parameters															
Bot. sampling														x	
Cld. base														x	
Constant press. htgs.												x			
Plankton													x		
Rawinsonde												x	x	x	x
Refract. ind.												x	x	x	
5 unusual U/A par.														x	x
Visibility												x		x	
Cld. tops														x	

TABLE 4-9I
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(NORTH PACIFIC WEST MDZ: 35 Buoy "System" Network)

System parameters	Requirements and locations									B C F	E S A F	U S C G	U S C N
	10	20	30	40	50	55, 50	100	200	300				
Ambient light												x	x
	1		2										
Ambient noise													x
	1												
Current velocity											x	x	x
	2		>2								x	x	x
Salinity											x	x	x
	>2										x	x	x
Sound speed											x	x	x
	2		<2								x	x	x
Transparency													x
	1												x
Water press.											x	x	x
	2		>2								x	x	x
Water temp.											x	x	x
	>2										x	x	x
Wave meas.											x	x	x
	>2										x	x	x
Air temp.											x	x	x
	>2										x	x	x
Atmos. elect.													x
	1												x
Atmos. press.											x	x	x
	>2										x	x	x
Dew point											x	x	x
	>2										x	x	x
Insolation													x
	1												x
Precip. rate											x	x	x
	1		<2								x	x	x
Wind velocity											x	x	x
	>2										x	x	x

TABLE 4-9I (Continued)
 REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
 (NORTH PACIFIC WEST MDZ: 35 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	S	U	S	U
	10	20	30	40	50	55	50	100	200	300	C	S	A	S	C	G
Bathymetry	1													x		
Total cloud amt.	2			>2								x		x		
Oxygen	1												x			
Tidal fluct.	1												x			
"Beyond 5-yr SOA" parameters																
Cld. base	2													x		
Cld. tops	1												x			
Constant press. htgs.	1											x				
Plankton	1											x		x		
Rawinsonde	>2											x	x	x	x	
Refract. ind.	2			>2								x		x		x
5 unusual U/A par.	1													x		
Visibility	2			>2								x		x		

TABLE 4-9J
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(SOUTH ATLANTIC MDZ: 33 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U	
	10	20	30	40	50	55	100	200	300	C	S	A	C	S	
										F	A	F	G	N	
Ambient light															x
Ambient noise															x
Current velocity											x	x	x	x	
Salinity											x	x	x	x	
Sound speed											x	x	x		
Transparency															x
Water press.											x	x	x		
Water temp.											x	x	x	x	
Wave meas.											x	x	x	x	
Air temp.											x	x	x	x	
Atmos. elect.															x
Atmos. press.											x	x	x	x	
Dew point											x	x	x	x	
Insolation											x				
Precip. rate											x		x	x	
Wind velocity											x	x	x	x	
	>2														

TABLE 4-9J (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(SOUTH ATLANTIC MDZ: 33 Buoy "System Network")

"Grey area" parameters	Requirements and locations										B	E	U	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	C	G
Total cloud amt.														x		x
	2															
Tidal fluct.																x
	1															
"Beyond 5-yr SOA" parameters																
Cld. base													x		x	
	2															
Cld. tops														x		
	1															
Rawinsonde													x	x		x
	>2															
Refract. ind.													x		x	
	2															
5 unusual U/A par.													x			
	1															
Visibility													x		x	
	2															

TABLE 4-9K
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(SOUTH PACIFIC EAST MDZ: 49 Buoy "System" Network)

System parameters	Requirements and locations								B	E	U	U	U	U	
	10	20	30	40	50	55	50	100	200	300	C	S	A	C	S
										F	A	F	G	N	
Ambient light															x
Ambient noise					1										x
Current velocity	2		>2								x	x	x		x
Salinity			>2								x	x	x		x
Sound speed			2								x				x
Transparency	1		2								x				x
Water press.			2								x				x
Water temp.											x	x	x		x
Wave meas.			>2								x	x			x
Air temp.											x	x	x		x
Atmos. elect.					1										x
Atmos. press.											x	x			x
Dew point											x	x			x
Insolation					1										x
Precip. rate					1		2					x			x
Wind velocity											x	x	x		x

TABLE 4-9K (Continued)
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(SOUTH PACIFIC EAST MDZ: 49 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	S
Total cloud amt.							2				A	F	G	N
Tidal fluct.							1					x	x	x
"Beyond 5-yr SOA" parameters														
Cld. base							2							x
Cld. tops							1							x
Constant press. htgs.							1					x		
Rawinsonde							>2					x	x	x
Refract. ind.							2					x	x	x
5 unusual U/A par.								>2						
Visibility							1							x
							2					x	x	

TABLE 4-9 L
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
SOUTH PACIFIC WEST MDZ: 35 Buoy "System" Network)

System parameters	Requirements and locations									B C F	S A F	U S G	U S N	
	10	20	30	40	50	55	50	100	200					
Ambient light														x
Ambient noise														x
Current velocity											x	x		x
Salinity											x	x	x	x
Sound speed											x		x	
Transparency														x
Water press.											x		x	
Water temp.											x	x	x	x
Wave meas.											x	x	x	x
Air temp.											x	x	x	x
Atmos. elect.														x
Atmos. press.											x	x	x	
Dew point											x	x	x	
Insolation														x
Precip. rate														x
Wind velocity											x	x	x	

TABLE 4-9 L (Continued)
 REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
 SOUTH PACIFIC WEST MDZ: 35 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	C	N
Total cloud amt.																x
	2															
Tidal fluct.																x
	1															
"Beyond 5-yr SOA" parameters																
Cld. base																x
	2															
Cld. tops																x
	1															
Constant press. htgs.	1											x				
Rawinsonde												x	x	x		
	>2															
Refract. ind.																x
	2															
5 unusual U/A par.																x
	1															
Visibility																x
	2															

TABLE 4-9M
REFINED NATIONAL OPERATIONAL PARAMETER REQUIREMENTS BY MDZ
(INDIAN OCEAN MDZ: 35 Buoy "System" Network)

System parameters	Requirements and locations									B	E	U	U	U	
	10	20	30	40	50	55, 50	100	200	300	C	S	A	S	G	
Ambient light															x
Ambient noise															x
Current velocity											x		x		
Salinity											x	x	x		
Sound speed											x		x		
Transparency															x
Water press.											x		x		
Water temp.											x	x	x		
Wave meas.											x	x	x		
Air temp.											x	x	x		
Atmos. elect.															x
Atmos. press.											x	x	x		
Dew point											x	x	x		
Insolation															x
Precip. rate															x
Wind velocity											x	x	x		

TABLE 4-9 M (Continued)
 Refined National Operational Parameter Requirements by MDZ
 (INDIAN OCEAN MDZ: 35 Buoy "System" Network)

"Grey area" parameters	Requirements and locations										B	E	U	U	U
	10	20	30	40	50	55	50	100	200	300	C	S	S	A	C
Total cloud amt.											F	A	F	G	N
															x
															x
Tidal fluct.															x
															x
"Beyond 5-yr SOA" parameters															
Cld. base															x
															x
Cld. tops															x
															x
Rawinsonde														x	x
														x	x
Refract. ind.															x
5 unusual U/A par.															x
															x
Visibility															x

Legend:

- a) • = Tentative "System" Observation Sites (100 to 150 n mi spacing)
- x = Non-"System" Observation Sites
- ⊗, ⊖ = More than 1 AMO Rqt.
- b) Total Numbers of Observation Sites: • = 25; x = 242; ⊖ = 18; ⊗ = 13

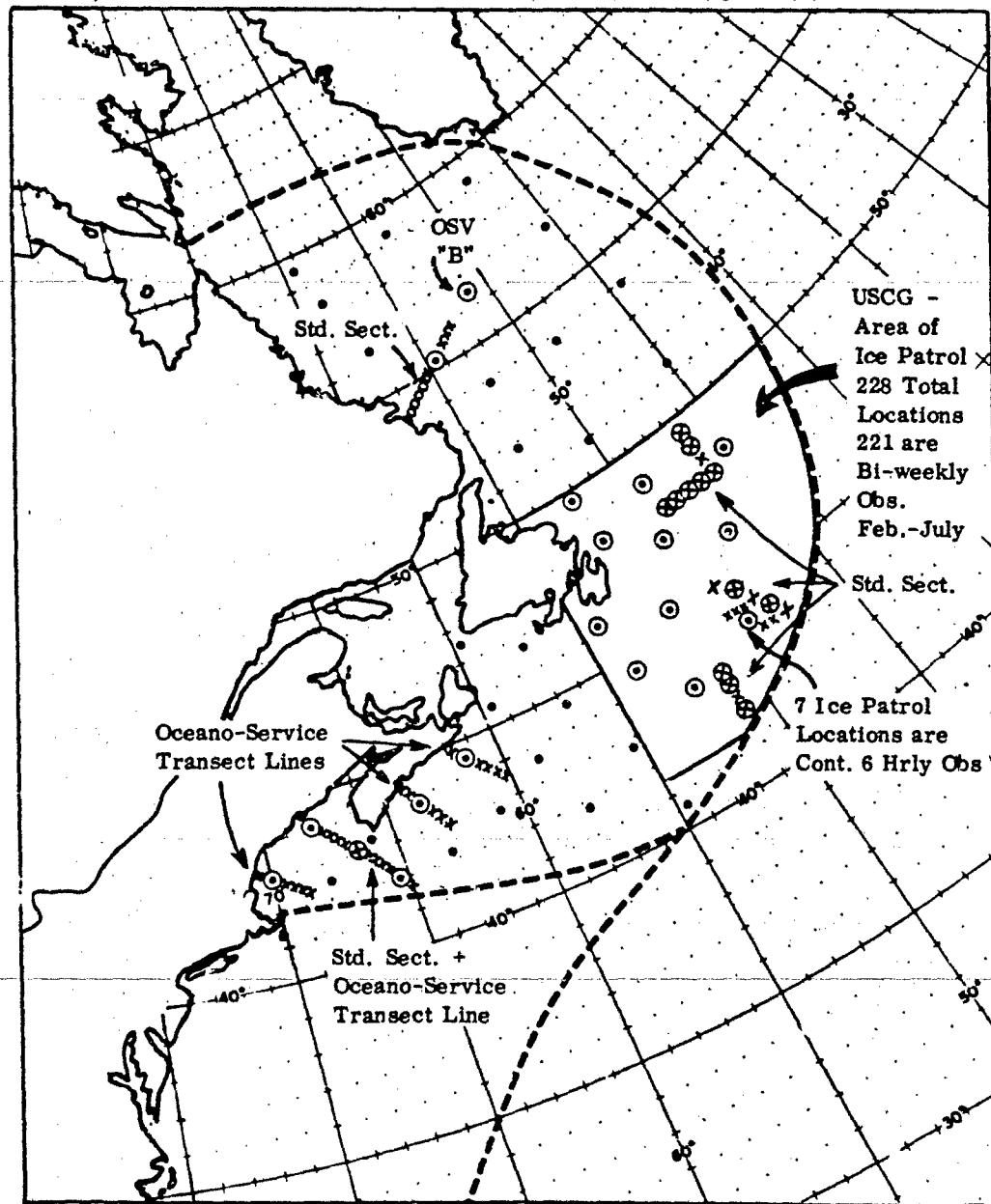


Fig. 4-4A. Tentative observation sites in Grand Banks MDZ for refined national operational data requirements.

Legend:

- a) • = Tentative "System" Observation Sites (100 to 150 n mi Spacing)
 - x = Non-"System" Observation Sites
 - ⊗, ⊕ = More than 1 AMO Rqt.
- b) Total Numbers of Observation Sites: • = 30; x = 83; ⊕ = 17, ⊗ = 10

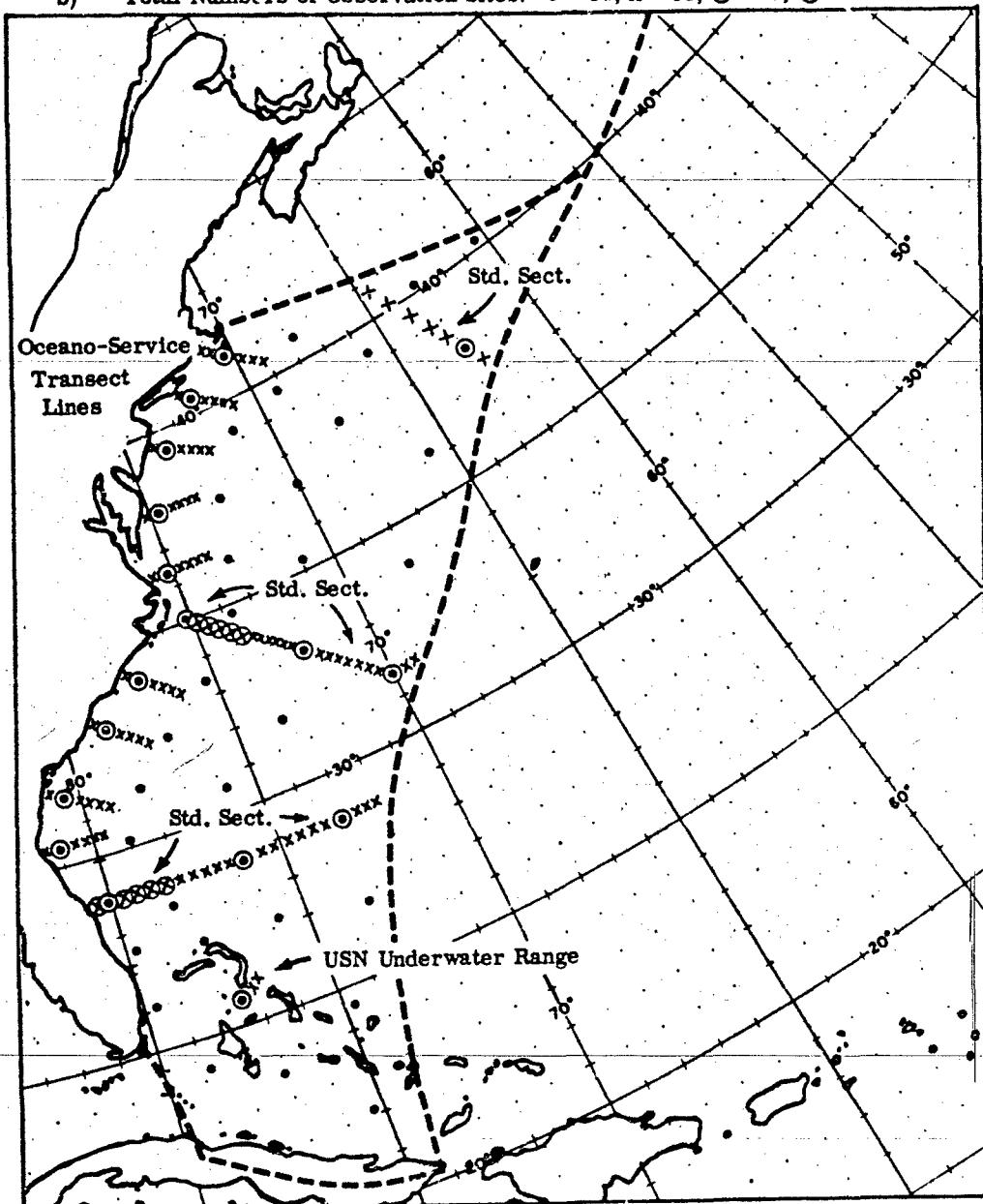


Fig. 4-4B. Tentative observation sites in East Coast MDZ for refined national operational data requirements.

Legend:

- a) \odot = Tentative "System" Observation Sites (100 to 150 n mi Spacing)
- \times = Non-"System" Observation Sites
- \otimes, \odot = More than 1 AMO Rqt.
- b) Total Numbers of Observation Sites: $\bullet = 38$; $\times = 4$; $\odot = 16$; $\otimes = 1$

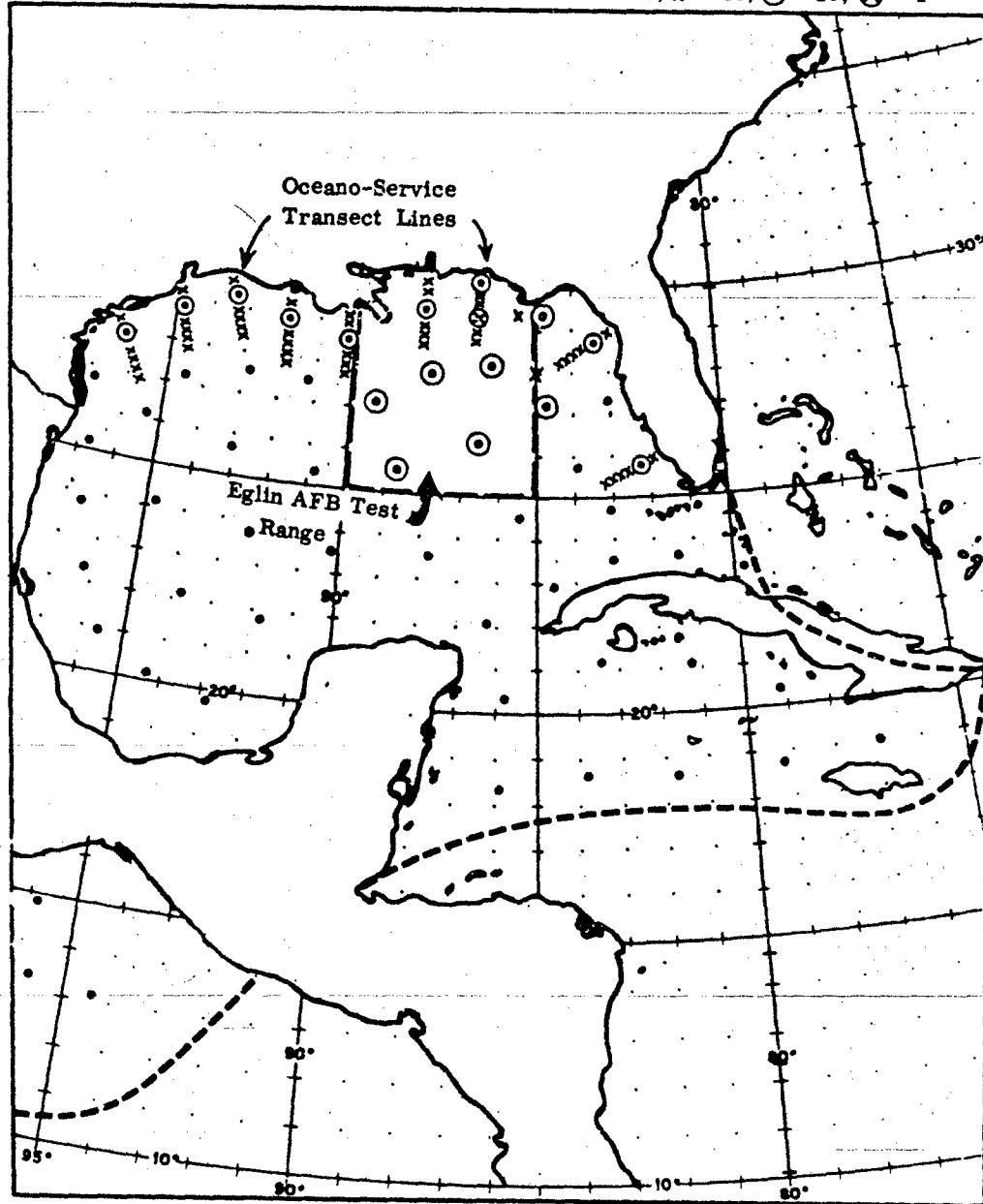


Fig. 4-4C. Tentative observation sites in Gulf of Mexico MDZ for refined national operational data requirements.

Legend:

- a) • = Tentative "System" Observation Sites -3 AMO Rqts. each (100 to 150 n mi Spacing)
- b) Total Numbers of Observation Sites: • = 36

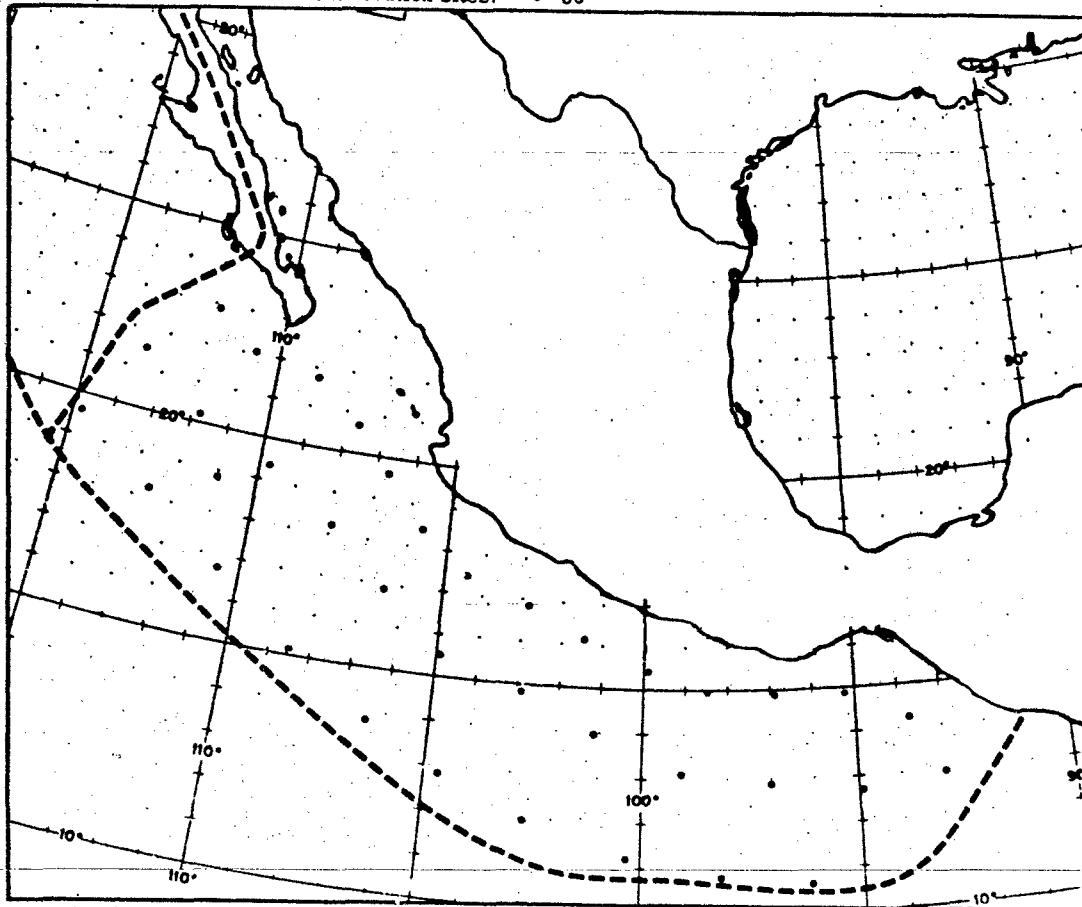


Fig. 4-4D. Tentative observation sites in Mexican Coast MDZ for refined national operational data requirements.

Legend:

- a) • = Tentative "System" Observation Sites -3 AMO Rqts. Each (100 to 150 n mi Spacing)
x = Non-"System" Observation Sites
◎ = More than 3 AMO Rqts.
⊗ = More than 1 AMO Rqt.
- b) Total Numbers of Observation Sites: • = 42; x = 61; ⊗ = 2; ◎ = 9

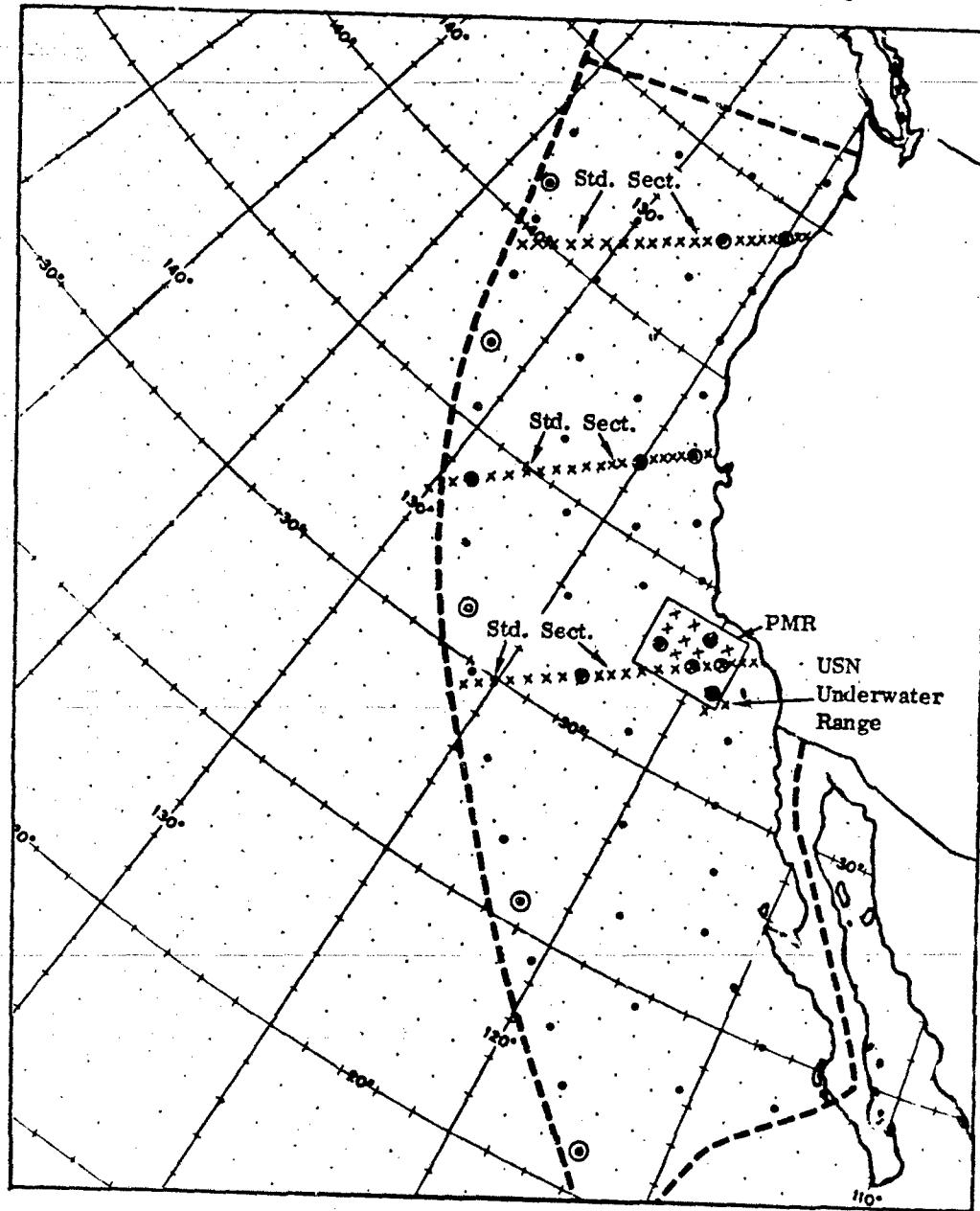


Fig. 4-4E. Tentative observation sites in West Coast MDZ for refined national operational data requirements.

Legend:

- a) • = Tentative "System" Observation Sites -2 AMO Rqts. Each
(100 to 150 n mi Spacing)
○ = More than 2 AMO Rqts.

b) Total Numbers of Observation Sites: • = 30; ○ = 18

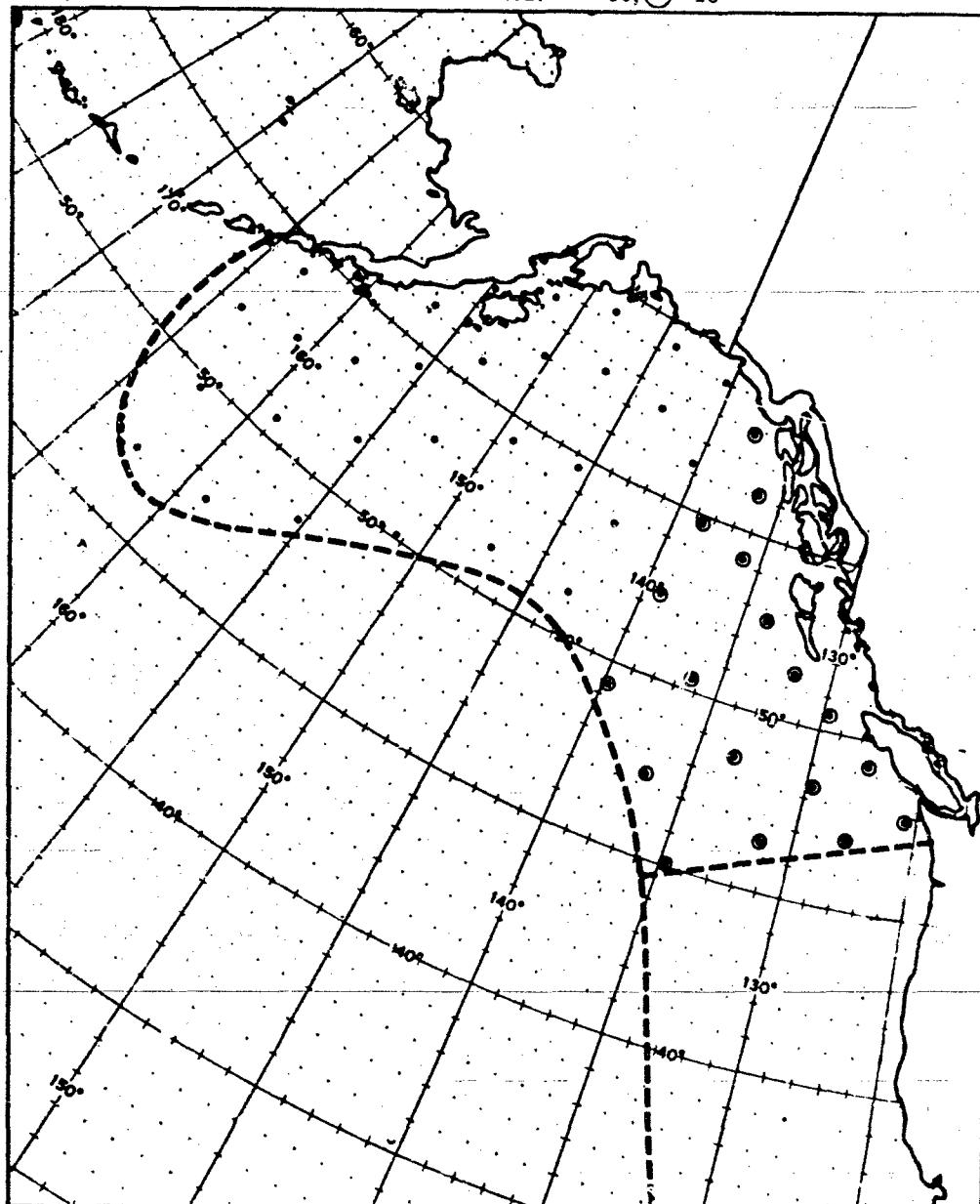


Fig. 4-4F. Tentative observation sites in Gulf of Alaska MDZ for refined national operational data requirements.

Legend:

- a) • = Tentative "System" Observation Sites -4 AMO Rqts. Each (600 n mi Spacing)
- x = Non—"System" Observation Sites
- ◎ = More than 4 AMO Rqts.

b) Total Numbers of Observation Sites: • = 30; x = 83; ◎ = 8; ○ = 4

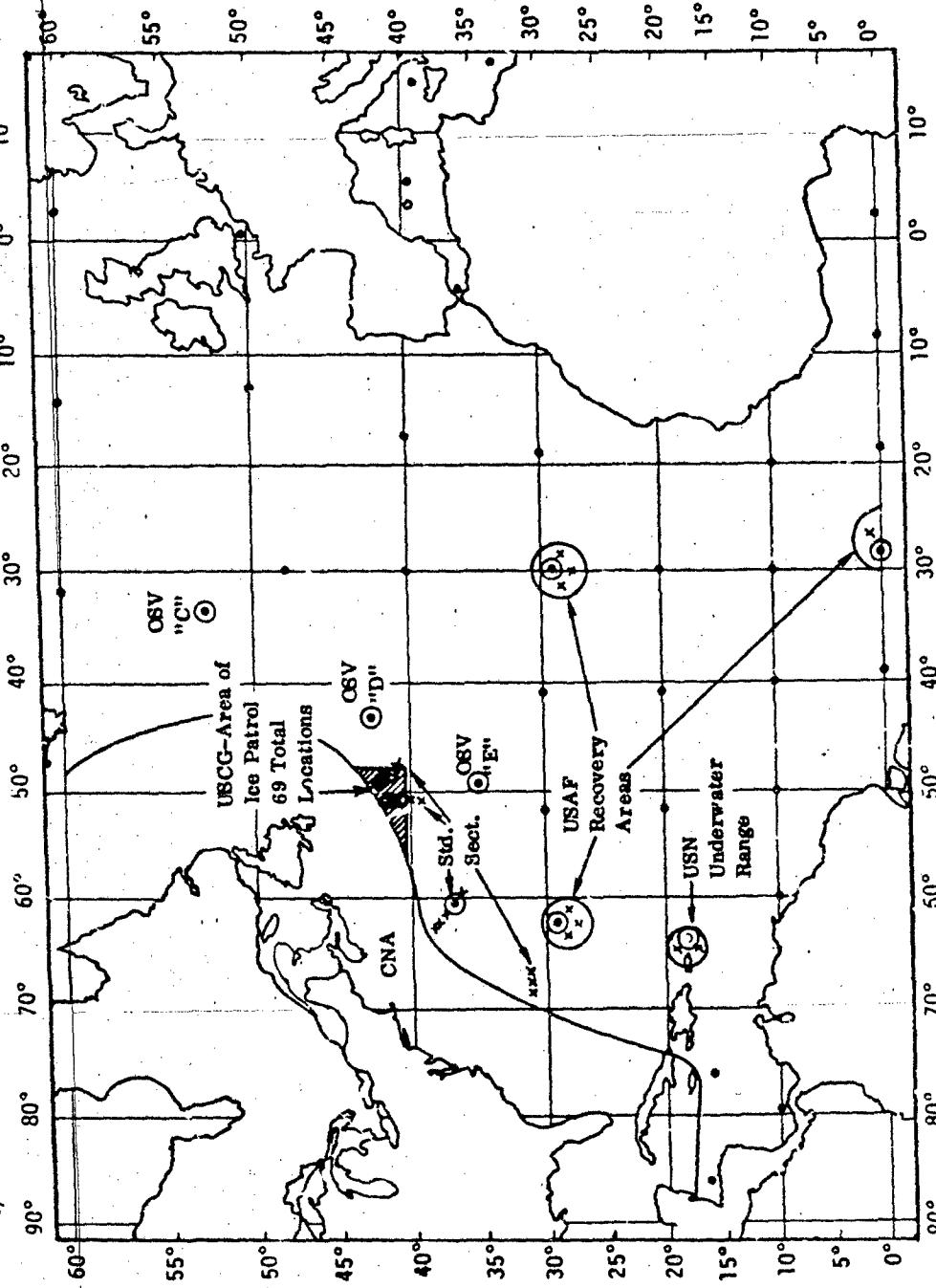


Fig. 4-4G. Tentative observation sites in North Atlantic MDZ for refined national operational data requirements.

Legend:

a) • = Tentative "System" Observation Sites -5 AMO Rqts. Each (600 n mi Spacing)

Non-"System" Observation Sites

More than 5 AMO Rqts.

More than 1 AMO Rqt.

Total Number of Observation Sites: • = 14; x = 5; ○ = 22; ⊕ = 4

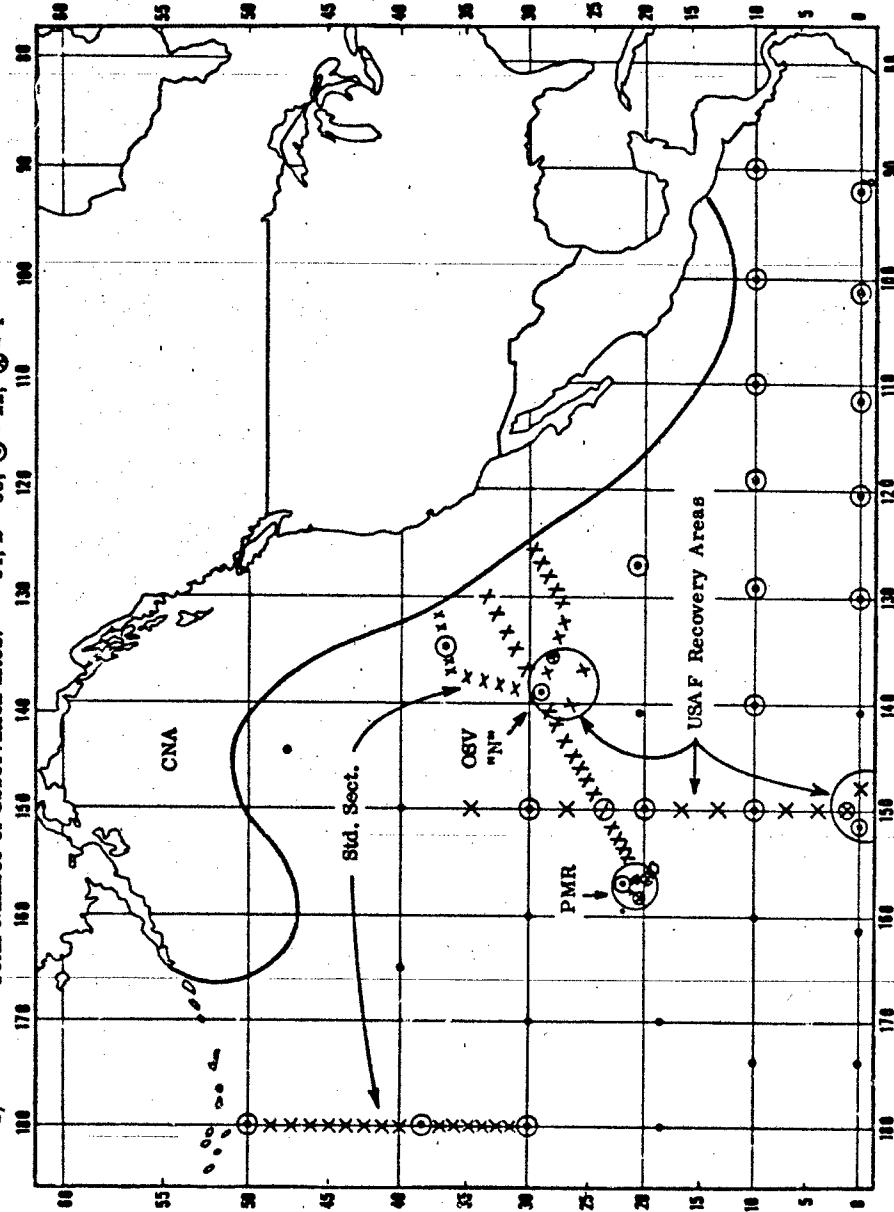


Fig. 4-41H. Tentative observation sites in North Pacific East MDZ for refined national operational data requirements.

Legend:

a) • = Tentative "System" Observation Sites -4 AMO Rqts. Each (600 n mi Spacing)

x = Non-"System" Observation Sites

(@) = More than 4 AMO Rqts.

b) Total Numbers of Observation Sites: • = 24; x = 17; @ = 11

90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 170° 160° 150° 140° 130° 120° 110° 100° 90°

60° 55° 50° 45° 40° 35° 30° 25° 20° 15° 10° 5° 0°

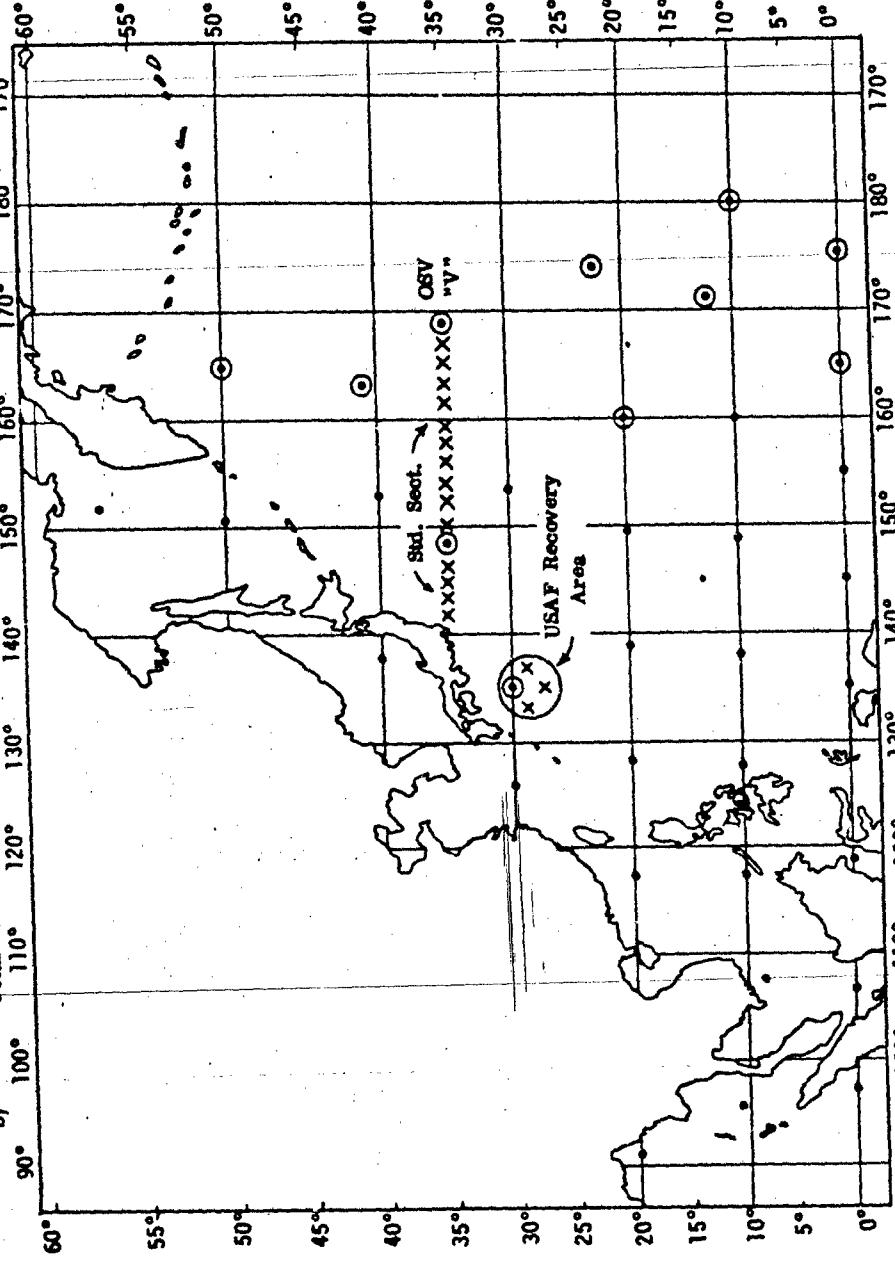


Fig. 4-41. Tentative observation sites in North Pacific West MDDZ for refined national operational data requirements.

Legend:

a) • = Tentative "System" Observation Sites -4 AMO Rqts. Each (600 n mi Spacing)
 b) x = Non-"System" Observation Sites

Total Numbers of Observation Sites: • = 33; x = 2

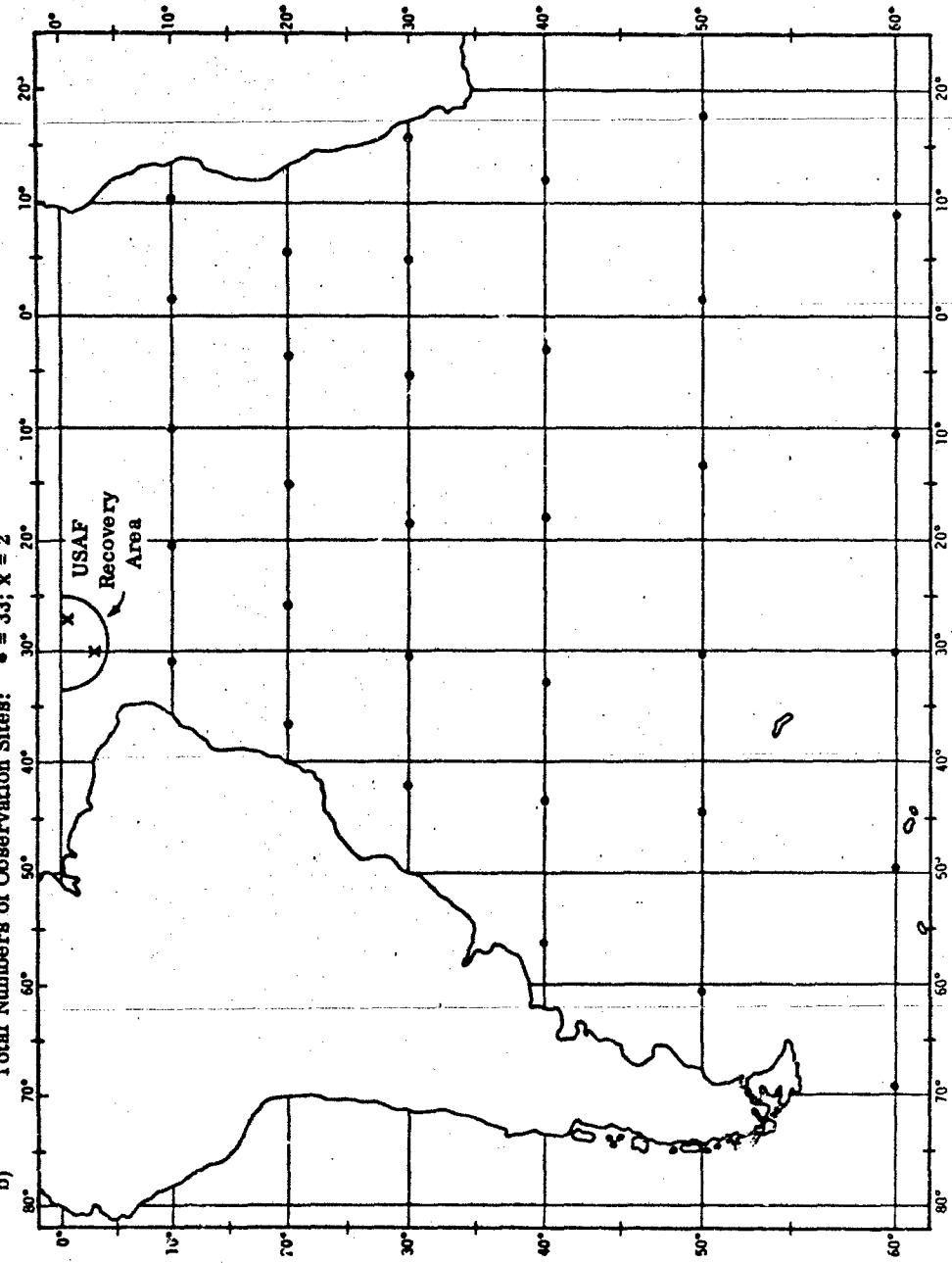


Fig. 4-4J. Tentative observation sites in South Atlantic MDZ for refined national operational data requirements.

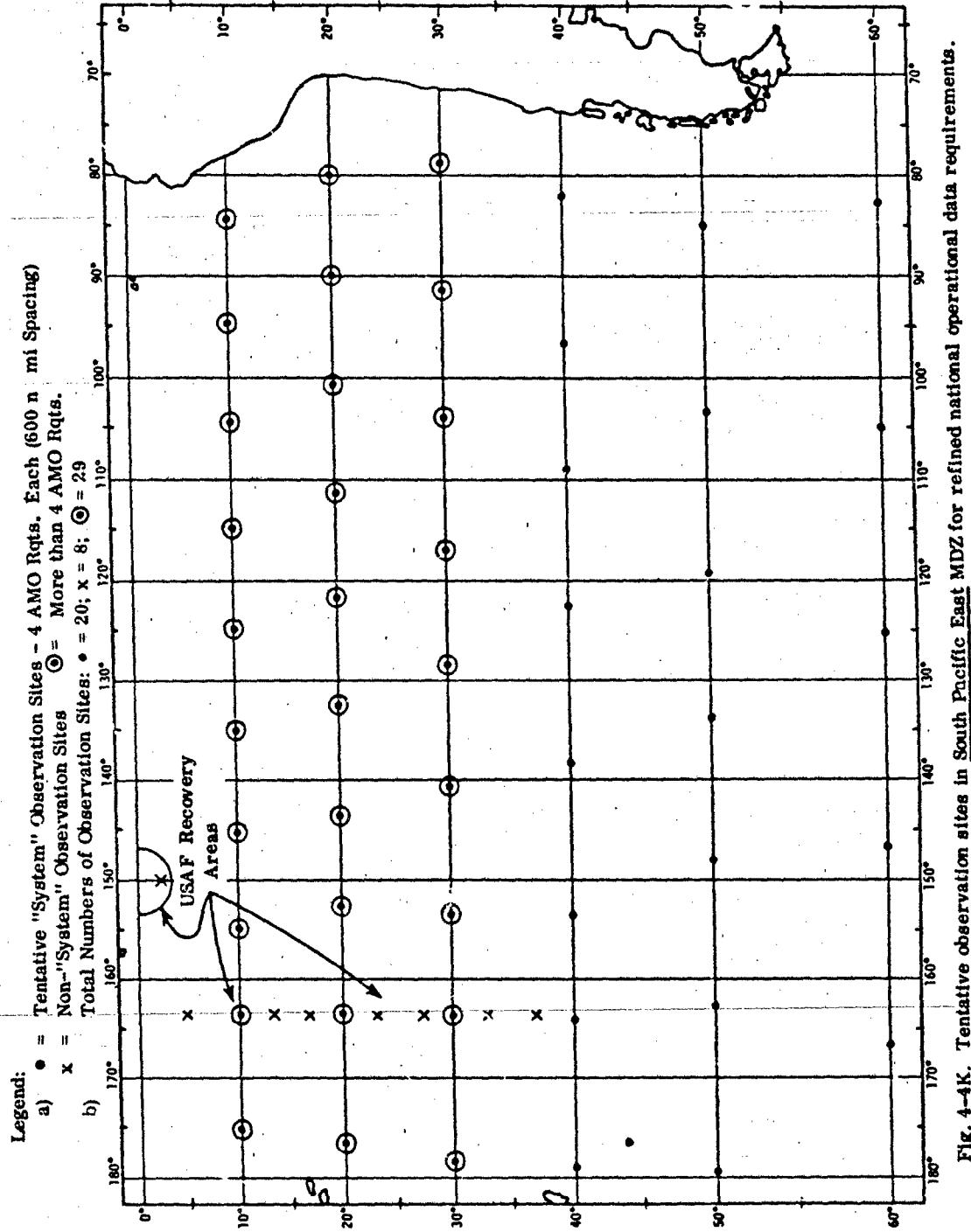


Fig. 4-4K. Tentative observation sites in South Pacific East MDZ for refined national operational data requirements.

Legend:

a) • = Tentative "System" Observation Sites - 4 AMO Rqts Each (600 n mi Spacing)
○ = More than 4 AMO Rqts.

b) Total Numbers of Observation Sites: • = 30; ○ = 5

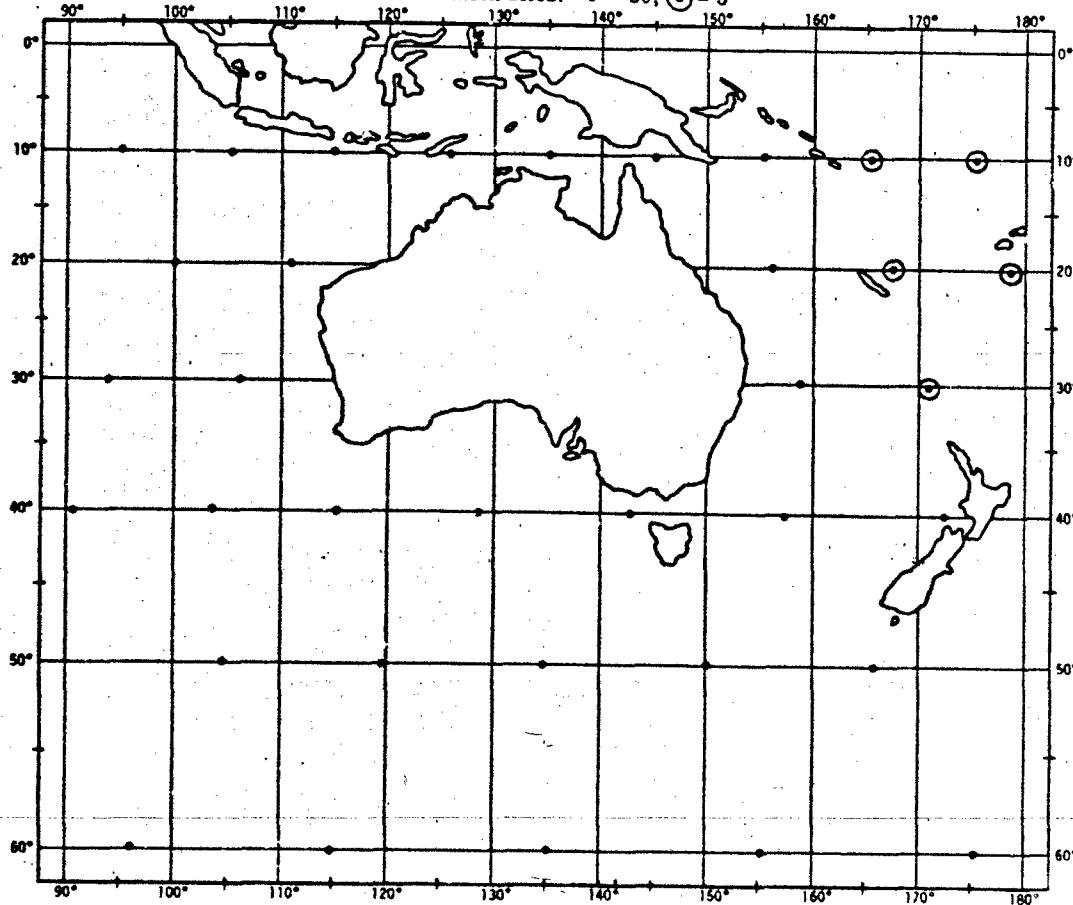


Fig. 4-4L Tentative observation sites in South Pacific West MDZ for refined national operational data requirements.

Legend:

a) • = Tentative "System" Observation Sites -4 AMO Rqts.

Each (600 n mi Spacing)

b) Total Number of Observation Sites: • = 35

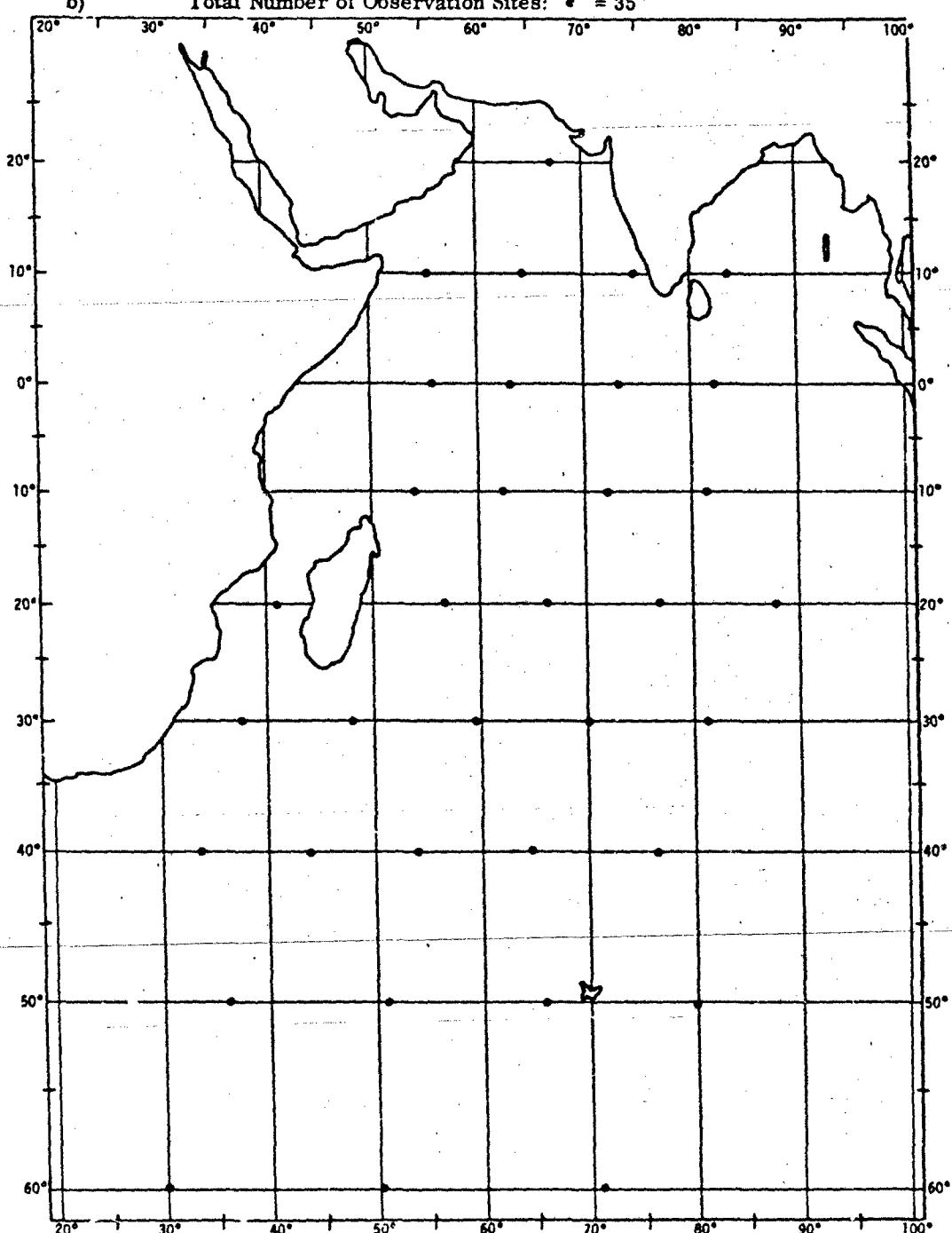


Fig. 4-4M. Tentative observation sites in Indian Ocean MDZ for refined national operational data requirements

4.3 Analysis of Refined Research Data Requirements

The procedure followed in the analysis of the refined research requirements was similar to, but not as extensive as, that used to analyze the refined operational requirements (Section 4.2). However, since the research requirements varied considerably, even within an agency, it was decided to make the analysis on an individual AMO basis rather than to collapse all of them into agency requirements as was done with the operational AMOs.

4.3.1 Summary of Refined Research Data Requirements

The summarized analysis results are presented in terms of refined AMO data requirements and are shown in tables similar to some of the tables in Section 4.1. There are 48 statements of data requirements from research activities in this refinement analysis. Thirty-three of these requirement statements incorporate new information; the remaining 15 of the 48 are 1967 statements of data requirements because refinement responses for them have not been received at the time of writing of this report. No changes were made in the required measurement characteristics for these 15 requirements statements.

4.3.1.1 Required Parameters

The summary of the parameters required by the 48 AMOs for both the DO and CNA research activities is given in Table 4-10. This table is divided into three parts: Part A gives the "system" parameters, part B lists the "grey area" parameters, and part C shows the "beyond 5-yr buoy SOA" parameters. Following the column of parameter names, there are four columns in the table labeled "initial" (collected in 1967), "added" or "deleted" during refinement (33 AMOs), and the resulting "total." The entries under these column headings are the numbers of AMO statements of data requirements involved. Thus, as seen in Table 4-10A, there were quite a few additions of "system" parameters made during the refinement process and a considerable number of deletions. In the resultant (total) column, of the 48 AMO requirement statements, there are no requirements for atmospheric electricity and only three for ambient noise, and six each for precipitation rate and sound speed. The other "system" parameters are required by at least about 25% of the research AMOs. The "system" parameters most generally required for support of research activities are

TABLE 4-10
PARAMETERS REQUIRED BY AMOS FOR RESEARCH ACTIVITIES
(Refined Requirements)

A. "System" Parameters

Parameters	Initial	Added	Deleted	Total
<u>Meteorological</u>				
Air temperature	18	6	2	22
Atmospheric electricity	0	0	0	0
Atmospheric pressure	13	4	1	16
Dew point	11	3	0	14
Insolation	8	6	0	14
Precipitation rate	4	3	1	6
Wind direction	30	4	2	32
Wind speed	30	4	2	32
<u>Oceanographic</u>				
Ambient light	4	10	0	14
Ambient noise	1	2	0	3
Current direction	45	4	9	40
Current speed	48	4	9	41
Salinity	35	3	3	35
Sound speed	6	0	0	6
Transparency	9	7	0	16
Water pressure	12	4	1	15
Water temperature	44	3	8	39
Wave direction	10	5	1	14
Wave height	16	3	0	19
Wave period	7	5	1	11

B. "Grey Area" Parameters

Parameters	Initial	Added	Deleted	Total
Albedo	1	0	0	1
Bathymetry	1	1	0	2
Biological growth	1	3	1	3
Bottom photography	0	2	0	2
Carbon dioxide	1	2	1	2
Elect. vol. conductivity	2	0	0	2
Fog	0	1	0	1
Ice accumulation	1	1	1	1
Inclination	1	0	0	1
Magnetic field int.	2	0	1	1
Mooring load	0	1	0	1
Oxygen	18	2	2	18
pH	?	1	0	2

TABLE 4-10**B. "Grey Area" Parameters (Continued)**

Parameters	Initial	Added	Deleted	Total
Pictures of fish	0	1	0	1
Propagation loss	0	2	0	2
Radiological chemicals	0	1	0	1
Resultant wind direction	2	0	0	2
Resultant wind speed	2	0	0	2
Sea state	3	0	1	2
Sediment deposit	0	1	0	1
Sub. surface insolation	0	1	0	1
Tidal fluctuation	7	3	1	9
Total cloud amount	3	3	0	6
Total radiation In	1	0	0	1
Total radiation Out	3	2	0	5
Turbidity	2	2	0	4
Vertical current	1	1	0	2
Water density	0	1	0	1
Water level	2	0	1	1
Wave direction spectrum	1	0	0	1

C. "Beyond 5-yr Buoy SOA" Parameters

	Initial	Added	Deleted	Total
Biological parameters	3	0	1	2
Bottom sampling	1	1	0	2
Chlorophyl	1	0	0	1
Cloud base	0	1	0	1
Cloud type	2	1	0	3
Dust	0	1	0	1
EH	1	0	0	1
Flux-heat	3	1	0	4
Flux-mass	1	0	0	1
Flux-momentum	1	0	0	1
Flux-water-vapor	1	0	0	1
Nitrates	1	0	0	1
Nutrients	3	0	0	3
Phosphates	2	0	0	2
Zooplankton	4	0	0	4
Rawin	1	0	0	1
Rawinsonde (T, P, RH, V)	2	0	0	2
Reynolds stress	2	0	1	1
Sediment load	1	0	0	1
Silicate	1	0	0	1
Toxic or trace metals	0	1	0	1

the same ones required by most operational activities. Certain parameters such as atmospheric electricity and ambient noise, etc. are required by only a small percentage of the users.

In part B of Table 4-10, oxygen is the most required parameter (by 18 AMOs), with tidal fluctuation a lagging second (9 AMOs), followed by total cloud amount (6 AMOs). The number of requirements is very small for most of the "grey area" parameters; less than 10% of the 48 AMOs. The "beyond the 5-yr buoy SOA" parameters (Table 4-10, part C) are each required by at least one activity; there are no requirements indicated by a large percentage of the activities for any particular parameter. Except possibly for oxygen and tidal fluctuation, the research requirements for "grey area" and "beyond the 5-yr buoy SOA" parameters are not likely to be involved in the development of the initial NDBS.

It is understood that although a given parameter may be required by only one activity, it may be essential to that activity and that activity may be of great importance to the nation. At this time, there continues to be a question concerning which parameters should be incorporated in the initial "system," but the relative importance of certain parameters is being established. Part of the information required for making this decision will be discussed in Section 5.0, "The Relative Importance of Required Parameters and Observing Layers."

4.3.1.2 Applicability of the Tentatively Proposed "System"

The summary of refined research data requirements indicates that, in addition to parameters, a number of measurement characteristics will be completely met or at least partially met by the tentatively proposed "system" sensing characteristics. Of the 48 research activities analyzed in this study, five (AMOs 6, 11, 17, 62, and 80) either do not have data requirements in the DO or CNA region or do not have requirements for "system" parameters. Therefore, the tentatively proposed "system" cannot be applied to the data requirements of these 5 AMOs. This leaves 43 research activities for which the "system" could have applicability. About half of these 43 research activities are interested in studying in detail the fine scale features of the marine environment, and for these the grid spacings of the "system" are too gross to obtain the desired resolution of phenomena. These fine grid requirements will

probably be satisfied by following some special approach recommended by a national scientific advisory group. However, for this category of research activities, the required parameters have been included in Table 4-10 and the complete statements of their data requirements, as understood at this time, are presented on their assessment sheets in Appendix IV. The data requirements of those research activities that can be met (or partially met) by the sensing capabilities of the tentatively proposed "system" will be discussed further.

4.3.1.2.1 Research Requirements Met by "System" Network Spacing

The tentatively proposed "system" that may become a major asset to the operational activities would also go far toward meeting the data requirements of many research activities. Nearly one-fourth of the 43 research requirement statements are quite well satisfied by the tentative "system", and another fourth would have at least 50% of their requirements satisfied. Thus, the tentative "system," with primary consideration given to operational requirements, could provide significant amounts of required data to about one-half of the 43 research activities. The research AMOs for which the 600 n. mi DO and 100 to 150 n. mi CNA spacing of the tentative "system" is satisfactory are listed as "met" in Table 4-11. Also shown in this table are: (a) the geographical area from which the AMO requires data, (b) the number of total requirements for each individual AMO for observations at sites in the DO and CNA "system" networks, (c) the number of "system" parameters that are met, (d) the number of required "grey area" and "considered beyond the 5-yr buoy SOA" parameters, and, finally, (e) remarks pertaining to some detail of the requirements that probably would not be met or that needed clarification. The ten AMOs listed in Table 4-11 (AMOs 31 to 37 were collapsed by ESSA into one requirement statement) represent a significant number of total requirements for 217 DO and 359 CNA observation sites. As previously, these total requirements are the sum of the requirements for observations at sites for each AMO with no elimination due to redundancy of observation sites among the ten AMOs. Thus, they represent ten separate buoy systems, each solely for the support of a particular AMO. Also listed in the table are the numbers of "system" parameters that are required by these ten AMOs and that are met by the tentative "system." Given, too, are the numbers of "grey area" parameters and those "considered beyond

TABLE 4-11
REQUIREMENTS OF RESEARCH AMOs MET BY
TENTATIVE "SYSTEM" NETWORK SPACING

Agency	AMO #	Geographic area	Total* requirements for observation sites		"System" parameter		Grey area parameter	Beyond 5-yr SOA parameter	Remarks
			DO	CNA	Met	Not met			
U.S. Army	5	CNA + DO Nr Hawaii	1	23	9	0	0	0	5 min synch. of observation not met. Requirement for Great Lakes not met
BCF-Miami	9A	GM, SA + NA 20°S to 20°N	27	4	8	0	1	2	Requirement for 200-kt wind speed questionable
BCF-Beaufort	10	Cont. shelf Maine to Texas	0	42	9	0	1	1	
BCF-Woods Hole	15	N.E. Cont. shelf	0	9	8	0	1	2	
ESSA	31-37	DO + CNA	see Remarks		4	0	1	0	Time samp. of 8 min not met. A few at a time for 30 days
USN-Mar. Eng. Lab	79	EC + Caribbean	0	1	6	0	3	1	30 min freq. of observation for water temperature not met
USN-NSR-DC	82	GB, EC, NA NPE + NPW	109	90	2	0	1		30 min duration of observation and 3 hr freq. of observation in DO not met
ONR-Scripps	84	WC, GA, NPE + NPW	30	103	17	0	10	4	Continuous duration of observation for some parameters and 1 hr freq. of observation not met
USN-NAVAIR SYSCOM	89A	CNA, NA NPE + NPW	50	86	12	0	1	0	30 sec z synch. of observation and requirement for Antarctic not met. Current accuracy may be too stringent
USN-NCEL	97	WC	0	1	5	0	1	0	2 sampling intensity would be met by "system" if site is in water 300 to 400 m deep
		Totals	217	359	80	0	20	10	

*Common use of a "system" network site by more than one set (AMO) of data requirements has not been considered in these columns.

the 5-yr buoy SOA" that would not be met, followed by remarks about certain characteristics of "system" parameters, most of which would not be met. For most AMOs, however, there are only minor entries in these last few columns. Only AMO 84 has many parameters that would not be met and, even in this case, more than half of the required parameters would be met (17 out of 31). There may be other ways of satisfying some of those research parameters not met by the tentative "system"; this will require special consideration when the relative worth of the various parameters to the researcher has been estimated by the user.

The requirements of the ten research AMOs that are met by the tentative "system" network spacing can be applied to the thirteen MDZs; the distribution of the requirements at "system" observation sites in the MDZs have been analyzed, as was done with the refined national operational requirements. The results of the analysis are presented in Table 4-12. The total individual AMO requirements for observation sites (217 DO and 359 CNA), equal in number to the total number at the bottom of Table 4-11 for the DO and CNA regions, are listed by MDZs in the first column after the MDZ initials. The manner in which these total requirements are distributed at "system" observation sites with 1, 2, 3, or 4 requirements per site is presented in the next four columns. The total number of "system" observation sites (buoys), with all redundant sites eliminated, required to meet the total DO and CNA requirements of the ten AMOs are listed in the final columns. Thus, only 119 DO "system" observation sites are required for meeting the 217 total DO refined research requirements of the ten AMOs, and 249 CNA "system" observation sites will satisfy the 359 total CNA research requirements. Thus, a significant number of the DO "system" network buoys (119 out of the total 261) and the CNA "system" network buoys (249 out of 279) are required by and can support quite well the refined data requirements of the ten research AMOs listed in Table 4-11, while at the same time serving the operational data needs discussed previously.

4.3.1.2.2 Research Requirements Partially Met by "System" Network Spacing

In addition to the ten research AMOs, listed in Table 4-1, having requirements "met" by the "system", there are twelve additional research AMOs that would be partially satisfied by the sensing capabilities of the tentatively proposed "system."

TABLE 4-12
NUMBER OF OBSERVATION SITES (BUOYS) REQUIRED FOR REFINED RESEARCH DATA
REQUIREMENTS MET BY "SYSTEM" NETWORK SPACING

MDZ	Total requirements for obs at sites	Deep Ocean					MDZ	Total requirements for obs at sites	Coastal North America					Total sites required (buoys)			
		Distribution of requirements at observation sites							Distribution of requirements at observation sites								
		1 Requirement	2 Requirements	3 Requirements	4 Requirements	1 Requirement			2 Requirements	3 Requirements	4 Requirements						
NA	72	14	14	10	0	38	GB	64	26	14	2	1	43				
NPE	67	12	18	5	1	36	EC	87	20	15	11	1	47				
NPW	68	6	21	6	0	35	GM	62	34	9	2	1	46				
SA	10	10	0	0	0	10	NC	16	12	2	0	0	14				
SPE	0	0	0	0	0	0	WC	66	37	13	1	0	51				
SPW	0	0	0	0	0	0	GA	64	33	14	1	0	48				
IND	0	0	0	0	0	0											
Total	217	44	53	21	1	119	Total	359	162	67	17	3	249				

*Common use of a "system" network site by more than one set (AMO) of data requirements has not been considered in this column.

Certain of the refined data requirements for these 12 AMOs are listed in Table 4-13. It is apparent that the DO and CNA "system" buoy networks would at least be contributory. This table is similar to Table 4-11. After the same identification columns for the agency name, AMO number, and geographical area of data interest, the next three columns are different from the corresponding two in Table 4-11 which are titled "total requirements for observation sites" (in DO and CNA). Because not all required observation sites are "system" network sites, as they were in the previous section, the first two of these three columns in Table 4-13 indicate the numbers of "system" observation sites that could support these requirements out of the total numbers of observation sites required. For example, in the data requirements of AMO 8, out of the total of four required observations at sites in the DO, there is only one DO "system" network site that could be of support; in the CNA, out of the required ninety observation sites there are fifty-four of the tentatively proposed "system" network sites that would serve. In the last of these three columns are listed the numbers and locations of required observation sites that are outside of the DO and CNA regions and, therefore, could not be served by the initial "system." The first two of these three

TABLE 4-13
REQUIREMENTS OF RESEARCH AND PARTIALLY MET BY
"SYSTEM" NETWORK SPACING

Agency	AMO	Geo-graphic area	Met by "system"		Other	"System" parameter		Grey area parameters	Beyond 5-yr SOA parameters	Remarks
			DO	CNA		Met	Not met			
BCF-Galveston	8	GM, NA	1/4	84/90	150 near shore	10	1	2	0	Range for insulation too large.
BCF-Stanford	13	MC, WC, GA, NPE, + SPF	39/98	15/13		13	1	6	1	6 hr avg. for current not met. Vertical spacing not met.
BCF-Booth Bay Harbor	16	Gulf of Maine	0	2/3		14	0	4	1	
USCG-Ice Patrol Research	26	GB	0	11/11	100 Sites N of 60°N	17	0	1	1	If 100 n. mi spacing OK in GB, then only 11 sites are needed.
HEW-PHS	40	GB, EC, GM, WC, + GA	0	42/74	Estuaries Number Unknown	17	0	12	11	
NSF-Lamont Geo-physical Observ.	52	NPE + NPW	5/8	0		3	0	0	0	Requirement not met when depth below 5000 m. Vertical spacing not met.
NSF-Lamont Geo. Observ.	54	Gibraltar + Carib.	3/4	0		2	0	0	0	20 min freq of ob. not met. Depth of 6000 m might be met.
NOO-ASW	66C	DO-CNA N. Hemis	109/173	29/29		5	0	0	0	Vertical spacing not met
ORL-Penn. State	78	DO-CNA	281/610	58/58		19	0	4	1	
USN-NAVAIR-SYSCOM	89B	CNA, NA, NPE+NPW	50/950	183/224	S. Pole Number Unknown	3	0	0	0	30 sec. Z synch of ob. not met. Current accuracy may be too stringent.
BCF-Honolulu	98	NPE	23/100	0		6	0	1	0	Area of major current requirement is uncertain. Vertical spacing not met.
BCF-Alaska	99	GA, NPE, + NPW	3/11	16/19	Estuaries N of 60°N 47 sites	8	0	0	0	Parameter characteristics mostly not stated.
		Totals	498/1982	410/623	297 + Number Unknown	117	2	30	18	

columns delineate the extent to which the tentatively proposed "system" could be of support to these twelve AMOs. The remainder of Table 4-13 is identical to Table 4-11. The totals at the bottom of Table 4-13 indicate that, without consideration of redundancy among these twelve AMOs at common observation sites, there are 495 out of the 1962 total AMO research requirements for DO observation sites that could be satisfied by "system" network sites. Similarly, for the CNA region, there are 410 "system" network sites that could serve the 523 total AMO requirements. Thus, the refined research requirements for these AMOs are better served in the CNA (80%) than in the DO (35%) but, even so, the requirements of more than half of the listed AMOs with observation sites in the DO and/or CNA are more than fifty per cent satisfied by the "system" network sites. In addition to the "system" network spacings being appropriate, the entires for the individual AMOs and the totals in the last four columns before "remarks" indicate that considerably more requirements for "system" parameters would be met than the combination of all other requirements for parameters that are not met. In fact, in the summation of individual AMO parameter requirements at the bottom of the table, 117 "system" parameter requirements would be met; requirements for two "system" parameters, thirty "grey area" parameters, and fifteen "beyond the 5-yr buoy SOA" parameters (total 47) would not be met by the tentatively proposed "system." Thus, over 70% of the parameters requested by these research AMOs would be met. This analysis has been made without benefit of guidance concerning the relative importance to the users of these various parameters. The intent has been to show the degree of "system" applicability to the research data requirements as they are understood at this time.

The requirements for "system" network and total observational sites of these twelve AMOs (listed in Table 4-13) can also be assigned to the thirteen MDZs and the distribution of the total requirements at "system" network sites can be analyzed as was done previously for all refined operational and ten other research AMO requirements. The results of this analysis, with all redundancy of common observation sites among these twelve AMOs removed, are presented in Table 4-14. The total individual AMO requirements for "system" observation sites (495 DO and 410 CNA) are the same as the totals for "system" sites in Table 4-13, but are listed in Table 4-14 by MDZs, as was done in Table 4-12 for the ten research AMOs met by the "system" network

TABLE 4-14
NUMBER OF OBSERVATION SITES (BUOYS) REQUIRED FOR REFINED RESEARCH DATA
REQUIREMENTS PARTIALLY MET BY "SYSTEM" NETWORK SPACING

MDZ	Total* Rqts for Obs at Sites	Deep Ocean					Total sites req'd (buoys)	MDZ	Coastal North America					Total sites req'd (buoys)			
		Distribution of Rqts at Obs sites							Distribution of Rqts at Obs sites								
		1 Rqt	2 Rqt	3 Rqt	4 Rqt	5 Rqt			1 Rqt	2 Rqt	3 Rqt	4 Rqt	5 Rqt				
NA	98	0	21	12	5	0	38	GB	58	20	13	4	0	0	37		
NPE	139	0	1	12	14	9	36	EC	65	13	23	2	0	0	38		
NPW	94	0	14	18	3	0	35	GM	139	0	27	23	4	0	54		
SA	33	33	0	0	0	0	33	MC	33	14	8	1	0	0	23		
SPE	61	37	12	0	0	0	49	WC	51	25	10	2	0	0	37		
SPW	35	35	0	0	0	0	35	GA	64	11	20	3	1	0	35		
IND	35	35	0	0	0	0	35										
Total	495	140	48	42	22	9	261	Total	410	83	101	35	5	0	224		

*Common use of a "system" network site by more than one set (AMO) of data requirements has not been considered in this column.

spacing. The manner of presenting the total requirements for observations at sites, the distribution of requirements at observation sites, and the resulting reduced number of required sites (buoys) is similar to that of Table 4-12. Thus, only 261 DO "system" observation sites are required for the 495 DO requirements in these twelve AMOs, and 224 CNA "system" sites are required for the 410 CNA requirements. Thus, all of the DO "system" network buoys (261 out of 261) and, again, a significant number of the CNA "system" network sites (224 out of the total 279) would provide at least partial support to the refined data requirements of the twelve research AMOs listed in Table 4-13, while at the same time serving the data needs of the ten research AMOs and the operational activities discussed earlier.

4.3.1.2.3 "System" Support for the Combined Research Requirements

As discussed in the previous two sections, the interpretation of support by the "system" for each of the two groups of research data requirements was considered separately as though each had its own exclusive data buoy system. Although such considerations are important to the analysis, from the viewpoint of the NDBS development the combined (or national) observation site requirements are of the greatest importance. Analysis of the combined research requirements for "system" observation sites by MDZs provides the results shown in Table 4-15 (in a form identical to that of Table 4-14). The total individual AMO requirements for observations at sites, summed at the bottom of the first columns with numbers under both DO (712) and CNA (769), are the same as the sum of the corresponding totals (217 + 495 DO and 359 + 410 CNA) from Table 4-12 for ten research AMOs and from Table 4-14 for the other twelve research AMOs respectively, all twenty-two of which are combined in this Table 4-15. The distribution of these requirements at "system" observation sites is shown in the next columns for DO and CNA and, finally, the reduced number of required "system" observation sites to meet the total requirements for observations at sites is listed with all redundancy for common use of sites removed. This final column shows that 261 DO "system" sites (buoys) and 270 CNA "system" sites (buoys) are required to meet the 712 DO and 769 CNA total research requirements for observations at "system" locations. Thus, all but nine CNA of the total "system" network sites (261 DO and 270 CNA) would provide

TABLE 4-15
NUMBER OF OBSERVATION SITES (BUOYS) REQUIRED FOR COMBINED REFINED RESEARCH
DATA REQUIREMENTS SUPPORTED BY "SYSTEM" NETWORK SPACING

A. Deep Ocean

MDZ	Total* Rqts for Obs at Sites	Distribution of Requirements at Observation sites								Total sites Req'd (buoys)
		1 Rqts	2 Rqts	3 Rqts	4 Rqts	5 Rqts	6 Rqts	7 Rqts	8 Rqts	
NA	170	0	0	14	7	6	7	4	0	38
NPE	206	0	0	1	9	5	9	8	4	36
NPW	162	0	0	8	6	14	5	2	0	35
SA	43	23	10	0	0	0	0	0	0	33
SPE	61	37	12	0	0	0	0	0	0	49
SPW	35	35	0	0	0	0	0	0	0	35
IND	35	35	0	0	0	0	0	0	0	35
Total	712	136	22	23	22	25	21	14	4	261

B. Coastal North America

MDZ	Total* Rqts for Obs at Sites	Distribution of Requirements at Observation sites								Total sites Req'd (buoys)
		1 Rqts	2 Rqts	3 Rqts	4 Rqts	5 Rqts	6 Rqts	7 Rqts	8 Rqts	
GB	122	5	11	20	3	1	3	0	0	43
EC	152	8	9	8	10	10	2	0	0	47
GM	201	0	5	21	17	9	0	1	1	54
MC	49	13	7	6	1	0	0	0	0	27
WC	117	12	18	15	6	0	0	0	0	51
GA	128	11	10	14	10	3	0	0	0	48
Total	769	49	60	84	47	23	5	1	1	270

*Common use of a "system" network site by more than one set (AMO) of data requirements has not been considered in this column.

support to the refined research data requirements, as understood at this time. In addition, the same "system" network buoys would support the marine data requirements of the nation's pertinent operational activities.

In demonstrating the general applicability of the tentatively proposed "system" network of buoys, the support to nearly half of the refined research AMO data requirements has been indicated above. While the proposed "system" is primarily for the support of refined operational needs, the importance of this additional support provided by the "system" for research requirements must not be overlooked. Of course, it is dependent upon the required length of the necessary observational programs. There is the question, "Will the data requirements be satisfied in a few days or weeks of data collection or, are these ongoing requirements that will continue for years like the operational requirements?" The answers for the twenty-two referenced research AMOs are listed in Table 4-16 and show that, with minor exceptions, the data requirements are for continuing data collection, similar to requirements for operational data. Such long-term research data-collection programs, in addition to the operational programs, lend added importance to the development planning of a multiple use national "system" network of data buoys.

This completes the discussion of the analysis of refined national requirements for marine meteorological and oceanographic data for both operational and research users. Some of the results presented in this section will be discussed further under "Conclusions," following a presentation in the next section of the status of the effort to obtain from the users estimates of the relative values of the various required parameters.

TABLE 4-16
PERIOD OF OBSERVATIONAL PROGRAMS TO SUPPORT REFINED RESEARCH AMO
DATA REQUIREMENTS

Agency	AMO No.	Geographic Area	Applicability of "System" Network Spacing	Required Period of Observational Program
U. S. Army	5	CNA + DO Nr Hawaii	Met	Continuous
BCF-Galveston	8	GM + NA	Partially Met	Continuous
BCF-Miami	9A	GM, SA + NA 20°S to 20°N	Met	Continuous
BCF-Beaufort	10	Cont. Shelf Maine to Tex.	Met	Continuous
BCF-Stanford	13	MC, WC, GA, NPE + SPE	Partially Met	Continuous
BCF-Woods Hole	15	N. E. Cont. Shelf	Met	Continuous
BCF-Booth Bay Harbor	16	Gulf of Maine	Partially Met	Continuous-With Scheduled Breaks
USCG-Ice Patrol Research	26	GB	Partially Met	Continuous-30-day Pd. (April thru July)
ESSA	31-37	DO + CNA	Met	Continuous-30 days in an area
HEW-PHS	40	GB, EC, GM, WC + GA	Partially Met	Continuous
NSF-Lamont Geophysical Observatory	52	NPE + NPW	Partially Met	Continuous
NSF-Lamont Geophysical Observatory	54	Gibraltar + Caribbean	Partially Met	Continuous with Scheduled Breaks
NOO - ASW	68C	DO + CNA No. Hemis.	Partially Met	Continuous
ORL-Penn. State	76	DO + CNA	Partially Met	Continuous
USN-Mar, Eng. Lab.	79	EC + Caribbean	Met	Continuous - With Scheduled Breaks
USN-NER + DC	82	GB, EC, NA, NPE + NPW	Met	Intermittent

TABLE 4-16
PERIOD OF OBSERVATIONAL PROGRAMS TO SUPPORT REFINED RESEARCH AMO
DATA REQUIREMENTS (Continued)

Agency	AMO No.	Geographic Area	Applicability of "System" Network Spacing	Required Period of Observational Program
ONR-Scripps	84	WC, GA, NPE, + NPW	Met	Continuous-Ends 1974
USN-Navair-Syscom	89A	CNA, NA, NPE + NPW	Met	Continuous
USN-Navair-Syscom	89B	CNA, NA, NPE + NPW	Partially Met	Continuous
USN-NCEL	97	WC	Met	Continuous-With Scheduled Breaks - Ends 1978
BCF-Honolulu	98	NPE	Partially Met	Continuous
BCF-Alaska	99	GA, NPE + NPW	Partially Met	Continuous

5.0 THE RELATIVE IMPORTANCE OF REQUIRED PARAMETERS AND OBSERVING LAYERS

Under contract to the USCG, TRC collected in 1967 and refined in 1968 the data requirements for oceanographic and marine meteorological parameters for 99 agency mission operations. During the course of the 1968 effort, it was recognized that some of the parameters were apparently more important than others and that these parameters would vary in importance within each of several observing layers. Therefore, the NDBS DPO assisted by TRC, solicited the relative importance of stated requirements for parameters and observing levels from four primary agencies with operational missions: BCF, ESSA, USCG, and USN. This effort was initiated in mid-1968 when the preliminary results of the data requirements refinement effort were made available to the NDBS DPO. Each of the four agencies was requested to rate in relation to the performance of its operational missions 50 required parameters distributed throughout seven layers in the vertical (some parameters appeared in more than one layer). The 50 operational parameters selected for this purpose were required by at least one of the four primary agencies and were judged to have the potential of general applicability for agency operational missions. The seven layers chosen divide the vertical extent of the data requirements (100,000 ft in the atmosphere down to the ocean bottom) into horizontal layers that relate to physical aspects of the environment, the observing platform, or observing technology. These seven layers are defined in Table 5-1.

**TABLE 5-1
DIVISION OF VERTICAL EXTENT OF DATA REQUIREMENTS
INTO OBSERVING LAYERS**

- Layer 1 - From 100,000 feet down to > 30,000 feet
- Layer 2 - From 30,000 feet down to > 45 feet
- Layer 3 - From 45 feet down to ocean surface
- Layer 4 - From ocean surface down through 10 meters
- Layer 5 - From > 10 meters down through 500 meters
- Layer 6 - From > 500 meters down through 5000 meters
- Layer 7 - At or near the bottom, regardless of depth

The rating sheet and the instructions for the estimation of the relative importance of operational parameters and observing layers are included as Appendix V. The rating criteria for estimating relative importance are presented in Table 5-2.

TABLE 5-2
CRITERIA FOR ESTIMATING RELATIVE VALUES
OF PARAMETERS AND LAYERS

Criteria	Value
Must have to satisfy missions	5, 4*
Important to satisfy missions	3, 2*
Useful to satisfy missions	1
Of no value to satisfy missions	0

Although two ratings were requested, one for those missions principally oriented toward atmospheric parameters and the other for those missions oriented toward oceanic parameters, the responding agencies preferred to make only one combined rating for all missions. Furthermore, each agency stated that the ratings were tentative and subject to change.

Table 5-3 contains tabulations of the four agencies' estimates of relative values of parameters and layers. The table shows the sum of all parameter relative values (maximum possible score of 20) and also the products of parameter and layer relative values for each agency and the sum of products for all four agencies (possible maximum score of 100). In addition, Table 5-3 shows by agencies which parameters were estimated as "must have to satisfy missions" in each layer. Clearly, certain parameters and certain layers have been judged more important by the agencies. The distribution of agency "musts" is illustrated by Table 5-4 which shows for each layer the total number of parameters that are a "must" for at least one, two, three, and four agencies. There is little question that the four agencies consider Layers 3, 4,

*The two numbers allow for the indication of a minor gradation of value.

TABLE 5-3
PARAMETER AND OBSERVING LAYER RELATIVE VALUES

Parameter	Agency Relative Values for Parameters and Layers								Parameter Num	Agency Parameter x Layer Products				Sum of Parameter x Layer Products	Parameter and Layer x "Bluet" for				
	ACF		ESEA		NAVY		UNCO			BCP		ESEA		NAVY			UNCO		
	Par	Lyr	Par	Lyr	Par	Lyr	Par	Lyr		BCP	ESEA	NAVY	UNCO	BCP	ESEA	NAVY	UNCO		
Layer 1: 100,000 ± Layer > 30,000 ft																			
1. Cloud Content	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
2. Cosmic Radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
3. Cloud Tops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4. Cloud Bases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5. Cloud Amount	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
6. Wind Speed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7. Wind Direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
8. Air Temperature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9. Height	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10. Atmos. Pressure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11. Dew Point/Humidity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12. Atmos. Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Layer 2: 30,000 ± Layer > 40,000 ft																			
1. Cloud Content	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
2. Cosmic Radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
3. Cloud Tops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4. Cloud Bases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5. Cloud Amount	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
6. Wind Speed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7. Wind Direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
8. Air Temperature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9. Height	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10. Atmos. Pressure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11. Dew Point/Humidity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12. Atmos. Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Layer 3: 40 ± Layer > 0 ft																			
1. Wind Speed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
2. Wind Direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
3. Air Temperature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4. Height	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5. Atmos. Pressure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
6. Dew Point/Humidity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7. Atmos. Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
8. Ionization	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9. Precipitation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10. Visibility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11. Mag. Field Decln.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12. Mag. Field Incln.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
13. Mag. Field Inten.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
14. Gravity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Layer 4: 0 ± Layer ± 10 m																			
1. Wave Period	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
2. Wave Direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
3. Wave Height	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4. Tidal Fluctuation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5. Ambient Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
6. Ambient Noise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7. Current Direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
8. Current Speed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9. Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10. Sound Speed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11. Transparency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12. Water Temperature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
13. Propagation Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
14. Depth	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
15. Water Pressure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
16. Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
17. Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
18. Phosphates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
19. Nitrates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
20. pH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
21. Nutrients	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
22. Plankton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
23. Chl-a/pigment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
24. Biological Growth	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
25. Photos of Fish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
26. Active Seismic	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

TABLE 5-3 (Continued)

Parameter	Agency Relative Values for Parameters and Layers								Parameter Sum	Agency Parameter x Layer Products				Sum of Parameter x Layer Products	Parameter and Layer a "Match" for			
	BCY		EMIA		NAVY		URCO			BCY		EMIA		NAVY		URCO		
	Par	Lyr	Par	Lyr	Par	Lyr	Par	Lyr		BCY	EMIA	NAVY	URCO	BCY	EMIA	NAVY	URCO	
Layer 5: 10 < Layer < 500 m																		
1. Ambient Light	3	3	0	0	0	0	0	0	7	18	0	0	18	0	0	36		
2. Ambient Noise	2	2	0	0	0	0	0	0	10	0	0	10	0	0	20			
3. Current Direction	4	4	0	0	0	0	0	0	17	20	20	15	25	25	25			
4. Current Speed	4	4	0	0	0	0	0	0	17	20	20	15	25	25	25			
5. Salinity	4	4	0	0	0	0	0	0	19	20	20	15	25	25	25			
6. Sound Speed	4	4	0	0	0	0	0	0	8	20	20	15	25	25	25			
7. Transparency	5	5	0	0	0	0	0	0	20	20	20	15	25	25	25			
8. Water Temperature	5	5	0	0	0	0	0	0	9	20	20	15	25	25	25			
9. Propagation Loss	1	1	0	0	0	0	0	0	4	5	5	5	5	5	100			
10. Depth	5	5	0	0	0	0	0	0	10	20	20	15	25	25	25			
11. Water Pressure	0	0	0	0	0	0	0	0	12	0	0	10	0	0	20			
12. Oxygen	2	2	0	0	0	0	0	0	15	20	20	15	25	25	25			
13. Carbon Dioxide	2	2	1	1	1	1	1	1	5	5	5	5	5	5	15			
14. Phosphates	2	2	0	0	0	0	0	0	7	15	0	0	15	0	0	25		
15. Nitrates	2	2	0	0	0	0	0	0	7	15	0	0	15	0	0	25		
16. pH	3	3	0	0	0	0	0	0	6	15	0	0	15	0	0	25		
17. Nutrients	2	2	0	0	0	0	0	0	7	15	0	0	15	0	0	25		
18. Plankton	2	2	0	0	0	0	0	0	9	20	0	0	15	0	0	25		
19. Chlorophyll	2	2	0	0	0	0	0	0	6	15	0	0	15	0	0	25		
20. Biological Growth	2	2	0	0	0	0	0	0	5	15	0	0	15	0	0	25		
21. Photos of Fish	2	2	0	0	0	0	0	0	5	15	0	0	15	0	0	25		
22. Vertical Current	1	1	0	0	0	0	0	0	2	10	0	0	10	0	0	20		
23. Active Sonar	4	4	0	0	0	0	0	0	4	20	0	0	15	0	0	30		
Layer 6: 500 < Layer < 5000 m																		
1. Ambient Noise	1	1	0	0	0	0	0	0	2	3	0	0	1	0	0	4		
2. Current Direction	3	3	0	0	0	0	0	0	11	9	20	15	25	25	25	42		
3. Current Speed	3	3	0	0	0	0	0	0	11	9	20	15	25	25	25	42		
4. Salinity	3	3	0	0	0	0	0	0	14	9	20	15	25	25	25	42		
5. Sound Speed	0	0	0	0	0	0	0	0	7	9	20	15	25	25	25	42		
6. Water Temperature	3	3	0	0	0	0	0	0	16	9	20	15	25	25	25	42		
7. Propagation Loss	1	1	0	0	0	0	0	0	3	2	0	0	1	0	0	7		
8. Depth	5	5	0	0	0	0	0	0	19	15	20	15	25	25	25	40		
9. Water Pressure	0	0	0	0	0	0	0	0	11	9	20	15	25	25	25	40		
10. Oxygen	2	2	1	1	1	1	1	1	7	9	20	15	25	25	25	40		
11. Carbon Dioxide	1	1	0	0	0	0	0	0	2	1	0	0	2	0	0	10		
12. Phosphates	2	2	0	0	0	0	0	0	1	7	9	0	1	0	0	10		
13. Nitrates	2	2	0	0	0	0	0	0	2	8	9	0	1	0	0	10		
14. pH	2	2	0	0	0	0	0	0	1	3	8	0	1	0	0	9		
15. Nutrients	2	2	0	0	0	0	0	0	3	8	9	0	1	0	0	9		
16. Photos of Fish	2	2	0	0	0	0	0	0	2	8	9	0	1	0	0	9		
17. Vertical Current	1	1	0	0	0	0	0	0	1	2	10	0	1	0	0	20		
18. Active Sonar	3	3	0	0	0	0	0	0	2	9	0	0	0	0	0	9		
Layer 7: At or near the bottom, regardless of depth																		
1. Tidal Fluctuation	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	20	
2. Ambient Noise	2	2	0	0	0	0	0	0	1	11	0	0	1	0	0	1	21	
3. Current Direction	4	4	0	0	0	0	0	0	11	20	20	15	25	25	25	47		
4. Current Speed	3	3	0	0	0	0	0	0	11	20	20	15	25	25	25	47		
5. Salinity	4	4	0	0	0	0	0	0	12	20	20	15	25	25	25	48		
6. Sound Speed	0	0	0	0	0	0	0	0	7	20	20	15	25	25	25	47		
7. Water Temperature	5	5	0	0	0	0	0	0	14	20	20	15	25	25	25	48		
8. Propagation Loss	1	1	0	0	0	0	0	0	3	2	0	0	1	0	0	7		
9. Depth	6	6	0	0	0	0	0	0	19	20	20	15	25	25	25	50		
10. Water Pressure	0	0	0	0	0	0	0	0	11	20	20	15	25	25	25	51		
11. Oxygen	2	2	1	1	1	1	1	1	8	18	0	0	1	0	0	24		
12. Carbon Dioxide	2	2	1	1	1	1	1	1	4	18	0	0	1	0	0	18		
13. Phosphates	2	2	0	0	0	0	0	0	7	12	0	0	1	0	0	18		
14. Nitrates	3	3	0	0	0	0	0	0	6	18	0	0	1	0	0	18		
15. pH	2	2	0	0	0	0	0	0	4	18	0	0	1	0	0	16		
16. Nutrients	2	2	0	0	0	0	0	0	7	18	0	0	1	0	0	18		
17. Biological Growth	2	2	0	0	0	0	0	0	8	18	0	0	1	0	0	18		
18. Photos of Fish	2	2	0	0	0	0	0	0	2	18	0	0	1	0	0	18		
19. Bottom Composition	1	1	0	0	0	0	0	0	1	11	0	0	4	1	1	26		
20. Photos of Bottoms	1	1	0	0	0	0	0	0	1	6	0	0	5	1	1	12		
21. Bathymetry	1	1	0	0	0	0	0	0	7	8	20	0	2	0	1	22		
22. Sediment Deposits	1	1	0	0	0	0	0	0	4	20	0	0	0	0	0	20		
23. Active Sonar	4	4	0	0	0	0	0	0	1	0	0	0	0	0	0	4		

TABLE 5-4
DISTRIBUTION OF "MUST HAVE" PARAMETERS

Layer	Total No. of Parameters in Layer	Total No. of Parameters that are a "Must" for at least			
		1 Agency	2 Agencies	3 Agencies	4 Agencies
1	11	10			
2	12	9	4		
3	14	13	8	6	5
4	26	16	10	8	5
5	23	11	6	5	3
6	18	7			
7	23	11	5		

and 5 to be the ones most important for the collection of marine data. Layers 2 and 7 are next in line, with Layers 1 and 6 last in this crude ranking.*

The parameters rated "must" by three or more agencies are listed in Table 5-5. Only Layers 3, 4, and 5 are involved here. There are 13 parameters included in Table 5-5 (atmospheric pressure and height have been counted as one parameter). All 13 of these parameters were among the 20 tentatively proposed for the hypothetical data buoy "system".

Parameters that were rated "must" by exactly two agencies are shown in Table 5-6 (this excludes the parameters in layers shown in Table 5-5). Five

*Using Table 5-4 as evidence of the "popularity" of layers could lead to unfortunate consequences. For example, certain data products prepared by ESSA are based on upper air measurements to at least 100,000 feet, and ESSA has indicated that upper air measurements are a "must" in Layer 1. Thus, to provide data for important ESSA data products, data collection from Layer 1 would be required, even though Table 5-4 might be construed to suggest that the relative importance of Layer 1 is small.

TABLE 5-5
PARAMETERS RATED "MUST" BY THREE OR MORE AGENCIES

<u>Layer 3</u>	<u>Layer 4</u>	<u>Layer 5</u>
Wind Speed	Wave Period	Current Direction
Wind Direction	Wave Direction	Current Speed
Air Temperature	Wave Height	Salinity
Height	Current Direction	Water Temperature
Atmos. Pressure	Current Speed	Depth
Dew Point/Humidity	Salinity	
	Water Temperature	
	Depth	

TABLE 5-6
PARAMETERS RATED "MUST" BY EXACTLY TWO AGENCIES

<u>Layer 2</u>	<u>Layer 3</u>	<u>Layer 4</u>	<u>Layer 5</u>	<u>Layer 7</u>
Height	Precipitation	Sound Speed	Water Pressure	Curr. Direction
Atmos. Pressure	Insolation	Water Pressure		Curr. Speed
Cloud Bases				Salinity
Cloud Amount				Water Temper- ature
				Depth

additional individual parameters have been added to the previous thirteen parameters of Table 5-5 (water pressure is considered to be the same as depth). Of these five, three (precipitation, insolation, and sound speed) are also among the 20 parameters in the tentatively proposed "system" characteristics.

Table 5-7 lists the parameters in layers rated a "must" by exactly one agency (parameters in layers in Tables 5-5 and 5-6 excluded). Fifteen additional parameters have been added to the previous total of 18. Thus, of the original 50 parameters considered,* a total of 35 parameters is rated as "must have to

*Count water pressure and height separately from depth and atmospheric pressure, respectively.

TABLE 5-7
PARAMETERS RATED "MUST" BY EXACTLY ONE AGENCY

<u>Layer 1</u>	<u>Layer 2</u>	<u>Layer 3</u>
Ozone Content	Cloud Tops	Visibility
Cloud Tops	Wind Speed	Mag. Field Declin.
Cloud Bases	Wind Direction	Mag. Field Inclin.
Cloud Amount	Air Temperature	Mag. Field Intensity
Wind Speed	Dew Point/Humidity	Gravity
Wind Direction		
Air Temperature		
Height		
Atmos. Pressure		
Dew Point/Humidity		
<u>Layer 4</u>	<u>Layer 5</u>	<u>Layer 6</u>
Tidal Fluctuation	Sound Speed	Current Direction
Transparency	Transparency	Current Speed
Propagation Loss	Oxygen	Salinity
Oxygen	Plankton	Sound Speed
Plankton	Active Sonar	Water Temperature
Active Sonar		Water Pressure
		Depth
<u>Layer 7</u>		
Tidal Fluctuation		
Sound Speed		
Water Pressure		
Bottom Composition		
Bathymetry		
Active Sonar		

satisfy mission" by at least one agency in at least one layer. The distribution by layer of "must" ratings for these 35 parameters is shown in Table 5-8. This table also indicates that 19 (or 17, eliminating redundancy) of these 35 parameters are included in the tentatively proposed sensing capabilities of the hypothetical data buoy "system." Of the 20 "system" parameters, the three not shown in Table 5-8 are atmospheric electricity, ambient light, and ambient noise. Atmospheric electricity is required in Layer 2 only by ESSA and in Layer 3 by ESSA and U.S. Navy. It was rated "useful to satisfy missions" in all entries. Ambient light was required in both

TABLE 5-8
PARAMETERS RATED "MUST" BY FOUR AGENCIES

Parameters	No. of Agencies for which the Parameter is a "Must"							Included in Hypothetical Data Buoy "System"	
	Layer								
	1	2	3	4	5	6	7		
Meteorological									
1. Air Temperature	1	1	4					X	
2. Atmos. Pressure	1	2	4					X	
3. Cloud Amount	1	2							
4. Cloud Bases	1	2							
5. Cloud Tops	1	1							
6. Dew Point/Humidity	1	1	4					X	
7. Gravity			1						
8. Height	1	2	3					X*	
9. Insolation			2						
10. Mag. Field Declin.			1						
11. Mag. Field Inclin.			1						
12. Mag. Field Intensity			1						
13. Ozone Content	1								
14. Precipitation			2					X	
15. Visibility			1						
16. Wind Direction	1	1	4					X	
17. Wind Speed	1	1	4					X	
Oceanographic									
18. Active Sonar				1	1		1		
19. Bathymetry							1		
20. Bottom Composition							1		
21. Current Direction				4	3	1	2	X	
22. Current Speed				4	3	1	2	X	
23. Depth				4	4	1	2	X**	
24. Oxygen				1	1				
25. Plankton				1	1				
26. Propagation Loss				1					
27. Salinity				4	4	1	2	X	
28. Sound Speed				2	1	1	1	X	
29. Tidal Fluctuation				1			1		
30. Transparency				1	1			X	
31. Water Pressure				2	2	1	1	X	
32. Water Temperature				4	4	1	2	X	
33. Wave Direction				3				X	
34. Wave Height				3				X	
35. Wave Period				3				X	

*Obtained from atmospheric pressure measurement

**Obtained from water pressure measurement

Layers 4 and 5 by BCF, U.S. Navy, and U.S. Coast Guard; BCF and U.S. Navy indicated that it was "important to satisfy missions" in both layers. Ambient noise was also required in Layers 4 and 5 by BCF, U.S. Navy, and U.S. Coast Guard. Again, BCF and U.S. Navy considered ambient noise "important to satisfy missions." Ambient noise was also required in Layer 6 for BCF and U.S. Navy, but only as "useful to satisfy missions." In Layer 7, ambient noise was required by BCF, U.S. Navy, and U.S. Coast Guard. BCF rated it as "important" while U.S. Navy and U.S. Coast Guard considered it only to be "useful."

It is recognized that soliciting relative importance of parameters and layers from four agencies with operational data requirements is only a first step in the effort to quantify data requirements for use as a guide in system development planning.

Some of the other important weighting factors are relative worth to the nation of agency missions, and/or (potential) benefits derived from the use of data products prepared by the agencies from the data to be collected. For example, if only one agency needs a certain parameter in a layer, but there is high utility of an ultimate data product based on the parameter in that layer, then the quantifying scheme should reflect these additional factors. Obviously, this initial effort to quantify requirements has not yet included all these relevant factors, nor is it suggested that the additional information would be easy to obtain. Of course, difficulty in obtaining further quantification of requirements information does not lessen its value for system development planning. Ultimately, it would appear desirable to evaluate the sensing characteristics of all complementary and competing data platforms that may comprise the total national marine meteorological and oceanographic data collection system.*

Some of the 50 parameters considered in this relative value investigation could be measured by the buoy tender when it services or overhauls the buoy. Among others, these might include bathymetry, bottom composition, gravity, plankton, and magnetic field declination, inclination, and intensity.

*An effort such as that suggested would lay the foundation for a cost-effectiveness analysis for the total data collection system, thus possibly leading to a better understanding of worth to the nation of agency missions.

In summary, this initial effort to determine the relative importance of required parameters and observing layers has produced results that may be helpful in selecting from the refined stated national data requirements those sensing characteristics most relevant for an initial NDBS. For data buoy platforms, the addition of other sensors, as need and sensor technology warrants it, would likely be a relatively easy task as long as provision is made for on-going sensor development in the evolutionary growth plan of the NDBS. It is concluded that additional effort in the area of relative values is warranted.

6.0 CONCLUSIONS

The conclusions discussed below are based on the results of analyses of U.S. Government Agency statements of data requirements as best understood today. This fact is stressed because the information on national marine meteorological and oceanographic data requirements that has been collected, compiled, and analyzed in 1968 are not exactly the same data requirements these agencies stated in 1967, or will probably state in the future. Thus, the conclusions given here are neither final nor unchanging. They are, however, the results of a seriously undertaken endeavor to provide comprehensive information at this time on the subject of national requirements for marine environmental data. As such, the conclusions presented in the following sections can be considered a reasonable basis for extracting guidance for marine data collection system development planning. It must be recognized, however, that future modifications in the statements of data requirements will doubtless occur, and evolutionary development planning, anticipating future changes, will be needed.

The conclusions from the results of the analysis of refined national data requirements for operational and research activities are listed and discussed below. There is no priority to the order in which these conclusions are listed. Further studies of cost-effectiveness and relative worth to the nation may modify some of these interim conclusions.

6.1 Evolutionary Nature of Data Requirements

- The continuing evolutionary nature of requirements for marine environmental data must be recognized. It is the result of numerous factors. Annual review and refinement of data requirements will probably be necessary throughout the foreseeable future.

Even in 1967, when the initial statements of data requirements were collected and compiled, it was understood that data requirements would continually evolve. For operational activities, change in data requirements would typically result from the implementation of new procedures (e.g., environmental prediction models). For research activities, change might stem from completion of an experiment or study and the beginning of a new study having different goals. These and other progressive steps

are most likely to provide the basis for new data requirements as the new data uses come into being.

In this study it was found that modifications in the initial 1967 statements of data requirements have already occurred. Changes during the 1968 data requirements refinement effort are indicated in Section 4.0. Appendix II contains a number of evolutionary changes, not the least of which was the product of better understanding of the data needs and equipment capabilities (buoy SOA). Most recently, changes were noted between the statements of refined operational data requirements and compilation of the relative importance of parameters and observing layers discussed in Section 5.0. As a case in point, one agency recently rated a parameter as a "must have" (a score of 5) while it was not even mentioned in that agency's earlier 1968 statement of refined data requirements. One can conclude that an educational process is under way, as originators of requirements give further and more penetrating consideration to their data requirements. Hopefully, the larger deficiencies in these statements have already been overcome.

Ignoring for the moment the impact of future uses of data, today's statements of data requirements appear to be approaching asymptotically, through a refinement process, the "real" requirements as they exist today. The success of this process will be much enhanced when adequate capability to collect data from the marine environment becomes available for use. Only then will it be possible for the agencies to validate or recommend changes in data requirements for particular data uses. In addition, as more information is obtained in the course of planned natural variability experiments in the marine environment, more scientific knowledge can be applied to give even greater realism to the statements of data requirements. For system development planning, the evolving nature of data requirements dictates that adequate flexibility be planned for the system and that the growth potential of the system anticipate the high probability of continuing evolution of the data requirements.

- Agency representatives have demonstrated a willingness and ability to estimate the relative importance to their operational missions of parameters and observing layers as part of the continued refinement of data requirements. A more intensive program to develop and exploit quantified ratings of this type should be undertaken.

The first attempt to obtain parameter and layer relative value estimates from four operational agencies - ESSA, BCF, U.S. Navy and U.S. Coast Guard - was successful. The results of these estimates from each agency have been combined to give average relative values for parameters and layers (see Section 5.0). Layer and parameter products were formed to show the relative importance of parameters in layers. Review of the relative value estimates obtained from the agencies suggests that some changes in the statements of refined data requirements may be in order. No information was solicited for the relative importance to the nation of the various missions of these agencies. It is clear, therefore, that value estimates can be made by the agencies; it would appear that the next step might logically be determination of the worth to the nation of agency missions in the marine environment.

6.2 Possible Sensing Characteristics for NDBS

One fact becomes obvious from studying the data requirements and their role as a basis for national data-buoy system planning and development: Requirements will be better understood and better specified when adequate data from the marine environment become available for use. Therefore, the implementation and operation of an early U.S. marine data acquisition system to obtain the needed data is highly desirable. The remainder of this section provides conclusions relative to the potential contribution of the NDBS in satisfying many of the stated data requirements. Concentration is placed on those parameters that tentatively have been judged to be important and might be satisfied by the NDBS. The final determination of what requirements will ultimately be met by the entire U.S. marine data acquisition system--of which the NDBS is to be but one element--will have to be resolved by future detailed studies of total system cost effectiveness and relative worth to the nation.

6.2.1 Possible DO and CNA Parameters

- The twenty parameters (Table 6-1) and their measurement characteristics tentatively proposed for inclusion in the NDBS during the assessment of refined data requirements (Appendix IV) appear to be generally acceptable to the agencies. They are suggested as representative of the basic sensing characteristics of a future DO or CNA NDBS.
Inclusion of some additional parameters of high common need appears

Indicated. Development of new sensing capabilities for the additional parameters (e.g., upper air parameters) appears worthy of further consideration.

TABLE 6-1
TWENTY BASIC PARAMETERS SUGGESTED TO BE
REPRESENTATIVE OF POSSIBLE INITIAL NDBS
SENSING CHARACTERISTICS

<u>Meteorological</u>	
1. Air temperature	5. Insolation
2. Atmospheric electricity	6. Precipitation rate
3. Atmospheric pressure	7. Wind direction
4. Dew point	8. Wind speed
<u>Oceanographic</u>	
1. Ambient light	7. Transparency
2. Ambient noise	8. Water pressure (depth)
3. Current direction	9. Water temperature
4. Current speed	10. Wave and swell direction
5. Salinity	11. Wave and swell height
6. Sound speed	12. Wave and swell period

During the 1968 analysis of refined data requirements, it became increasingly apparent that the required parameters did not all have the same general applicability or equal importance, because of the wide variety of missions involved. The possibility of measuring certain parameters from unattended buoys appeared rather remote. It was suggested early in the analysis that the total number of parameters tentatively suggested for an NDBS (Table 4-2) could be sharply reduced by using the selection criterion of common requirements among the agencies for the parameters judged measurable from buoys. Consideration of commonality of refined DO requirements, however, led to the obvious need in an initial NDBS for the 20 "system" parameters, plus total cloud amount, upper air sounding data, and visibility. The counterpart "system" for the CNA region incorporated, for general requirements, standard

upper-air sounding data and 15 of the 20 "system" parameters (exceptions: ambient light, ambient noise, atmospheric electricity, insolation and transparency). All "system" parameters, except ambient noise, were required for a significant portion of the CNA region. There were additional parameter requirements in specified areas of limited size. Of course, the final decision of which parameter requirements will be met by the NDBS will have to be justified on the basis of further cost-effectiveness studies that will also consider the feasibility of developments to meet sensor capability requirements. In turn, all such results of analyses will have to be weighted by the value to the nation of each agency's mission. This important final step has not yet been undertaken.

Another way of relating needed NDBS capabilities to marine data collection requirements can be approached by reviewing the projected 5-year buoy SOA. The 1967 statements of data requirements (Table 2-2) indicated there were 81 different parameters (or groups of parameters) of which 29 were judged in 1967 to be beyond the 5-year buoy SOA. Of the remaining 52 parameters, 9 were considered to be secondary (or derived) parameters. Of the remaining 43 primary parameters measurable by buoys, 6 were considered to be better measured from some non-buoy platform, and the obtaining of an observation from a data buoy for 17 additional parameters was considered to have potential technical development problems associated with it. This left the 20 parameters which, in this effort, have been called the tentatively proposed "system" parameters. These are judged to be measurable from buoys using sensing equipment that can be developed within 5 years or less to have all the desired characteristics (range, accuracy, reliability, etc.). These 20 basic and important required parameters judged measurable from an NDBS buoy are given in Table 6-1.

Of course, the data requirements dictate the need for more parameters than the 20 in Table 6-1. (These additional parameters are given in Table 4-2; they include total cloud amount, upper air soundings, visibility, etc.). All existing (and potential) required parameters will have to be considered on the basis of continued interaction with the agencies, the results of detailed cost-effectiveness studies including platforms other than buoys, further investigation of relative values, and benefits from data use. All facets of this study substantiate the conclusion that the 20 parameters in Table 6-1 are likely candidates for inclusion in an early NDBS.

6.2.2 Possible DO and CNA Initial Buoy Locations

- Horizontal spacings for Deep Ocean buoy networks of 600 n mi and Coastal North America network spacings of 100 to 150 n mi appear to be generally acceptable for an initial NDBS and appear to serve the stated needs of many activities. A total of 261 DO and 279 CNA data buoys would be needed to satisfy these horizontal spacing requirements from 60°N to 60°S.

The 20 DO and CNA parameters discussed in the previous section may ultimately be joined by more parameters, through additional studies and negotiations with individual agencies. But it will be necessary to do more than merely define the "what" and the "how" of meeting the DO and CNA data requirements; the specifics of "where" are also important, especially in regard to system costs for initial implementation. It is almost axiomatic that specific data observing locations should be resolved to meet the needs of a large majority of the users, for then other sensors can be added to the buoys, increasing the system sensing capability as the need (or ability) to measure more parameters arises.

The geographical area from which data were required and the required horizontal spacing of observation sites were specified in the measurement characteristics of the refined data requirements analyzed in this study. Specifically, this study has delineated locations where observation sites (buoys) would appear to satisfy combined requirements for data collection. In a few cases, specific locations were stated in the data requirements but, in general, the requirements indicated only a geographic area, such as the ice patrol region or the world's oceans between 50°N and 60°S latitude. Thus, for lack of more specific guidance from the statements of requirements, the task of selecting observing sites that would satisfy the largest number of observation requirements was undertaken as part of the general assessment of refined 1968 requirements. For the few observing locations specified in the agency requirements, it was usually possible to identify commonality of other requirements at the specified locations. The general areas of data interests of each operational activity and the number of required buoys that are shown in the charts in Appendix III, part A were collapsed into the charts of Fig. 4-4 (A-M). These show the tentative buoy sites for

all the refined national operational data requirements in the thirteen Modular Deployment Zones. The refined research data requirements were also assessed in relationship to the tentatively proposed "system" buoy sites indicated in Fig. 4-4.

In this list of conclusions, stress is placed on delineating where observation sites might be located and demonstrating for this outlined tentative "system" network of buoys applicability to the observational spacing specified in the combined operational and research marine data requirements. Table 6-2 illustrates the applicability of the "system" network of buoys to the national requirements (as understood at this time) and the distribution of requirements for observations by the various agencies at "system" network sites. The total requirements for observations at tentatively proposed "system" sites are listed for each of the 13 DO and CNA MDZs in the "Total Rqts . . ." column of Table 6-2. These are the sum of the requirements from each pertinent AMO without elimination of redundancy by common use of a "system" buoy site. Thus, there are 330 total observational requirements for observations at sites in the North Atlantic DO MDZ, but only 38 sites are needed to satisfy these. All of these sites satisfy 7 to 12 observational requirements. For example, in the third column of requirements distribution for the NA MDZ, the entry "9" indicates there are nine "system" buoy sites that each satisfy seven different requirements for observations. There are 1,893 requirements among all MDZs in the DO and a corresponding sum of 1,353 among all CNA MDZs. The distribution of these at "system" network buoy sites is made clear in Table 6-2. For the DO, the 1,893 total requirements for observations at sites are met at 261 "system" buoy sites supporting 5 to 15 different requirements at each site. In the CNA, 1,353 requirements are satisfied by 279 "system" sites, each supporting 2 to 10 different observational requirements.

Thus, a 7:1 average ratio of (operational plus research) requirements-for-observations-at-sites to "system" observational sites is achieved in the Deep Ocean MDZs, and approximately a 5:1 average ratio of requirements to "system" sites is established in the Coastal North America MDZs. This high degree of utilization of data buoy sensor platforms is accomplished through the use of 540 buoys: 261 in the Deep Oceans and 279 in the Coastal North America region. This delineation of the multiple use of the tentatively proposed buoy sites for a possible initial NDBS demonstrates the applicability of the tentatively proposed "system". The tentatively proposed DO

TABLE 6-2
**NUMBER OF "SYSTEM" OBSERVATION SITES REQUIRED FOR NATIONAL REFINED
 OPERATIONAL AND RESEARCH DATA REQUIREMENTS**

A. Deep Ocean

MDZ	Total* Rqts for Obs at Sites	Distribution of Requirements at "System" Observation Sites												Total Sites Req'd (buoys)
		5 Rqts	6 Rqts	7 Rqts	8 Rqts	9 Rqts	10 Rqts	11 Rqts	12 Rqts	13 Rqts	14 Rqts	15 Rqts		
NA	330			9	11	6	8	3	1				38	
NPC	413					2	10	8	8	3	3	2	36	
NPW	314			8	5	8	9	4	1				35	
SA	175	23	10										33	
SPE	306	20	5	16	8								49	
SPW	180	30	5										35	
IND	175	35	.										35	
Total	1893	108	20	33	24	16	27	15	10	3	3	2	261	

B. Coastal North America

MDZ	Total Rqts for Obs at Sites	Distribution of Requirements at "System" Observation Sites										Total Sites Req'd (buoys)
		2 Rqts	3 Rqts	4 Rqts	5 Rqts	6 Rqts	7 Rqts	8 Rqts	9 Rqts	10 Rqts		
GB	183	4	8	16	9	2	2	2				43
EC	218	7	9	5	9	8	8	1				47
GM	273		4	20	11	12	4	2		1		54
MC	157		9	13	7	6	1					36
WC	280			11	17	12	10		1			51
GA	242		7	11	10	13	7					48
Total	1353	11	37	76	63	53	32	5	1	1		279

*Common application of a "system" network site to more than one set (AMO) of data requirements has not been considered in this column.

and CNA networks of buoys meet the requirements of most of the operational and research activities submitting statements of refined data requirements in 1968 or initial data requirements in 1967.

Details of the multiple use of each buoy site for operational and for research requirements are presented in the 13 maps of Fig. 6-1 (A-M).* These maps show approximate observation sites for tentatively proposed initial NDBS networks for each of the 13 MDZs. While it is clearly recognized that all NDBS operational sites must be coordinated and approved by the agencies, it is believed that the maps in Fig. 6-1 will serve as a basis for stimulating discussion among agencies and throughout the community of research and operational data users. Figures 6-2 and 6-3 show the "system" networks of observation sites in the complete CNA and DO regions. These networks are representative of a possible future NDBS.

*At each observation site (buoy), the number of operational requirements for observations at the site is given, followed by the comparable number of research requirements: e.g., 8(2) implies 8 operational and 2 research requirements for observations at that site.

Legend:

- a) "8(2)" Equals 8 Operational and 2 Research Requirements
for Observations at Site
- b) Total Sites = 43

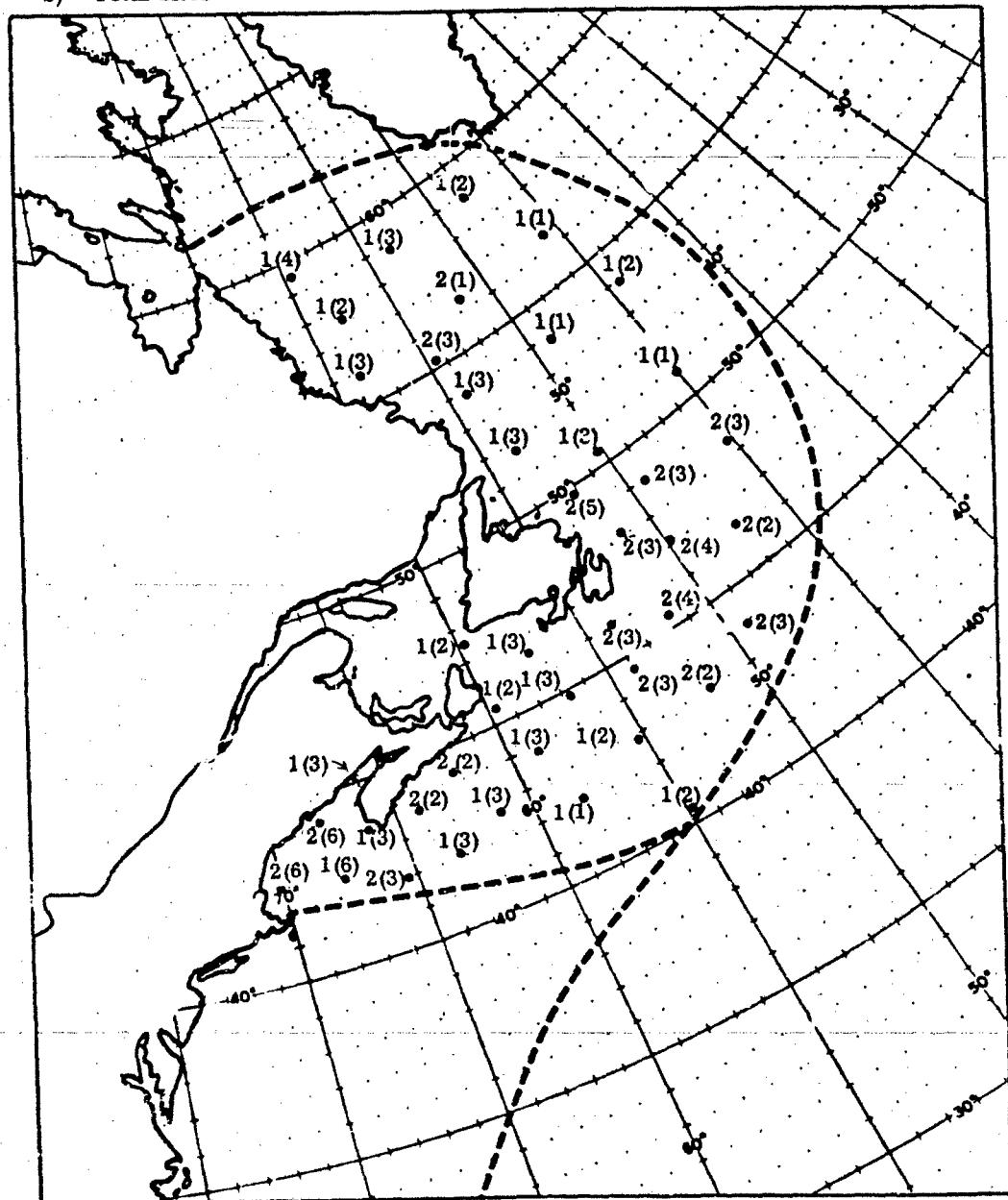


Fig. 6-1A. Distribution in Grand Banks MDZ of refined operational and research national data requirements at observational sites

Legend:

- a) "8(2)" Equals 8 Operational and 2 Research Requirements
for Observations at Site
- b) Total Sites = 47

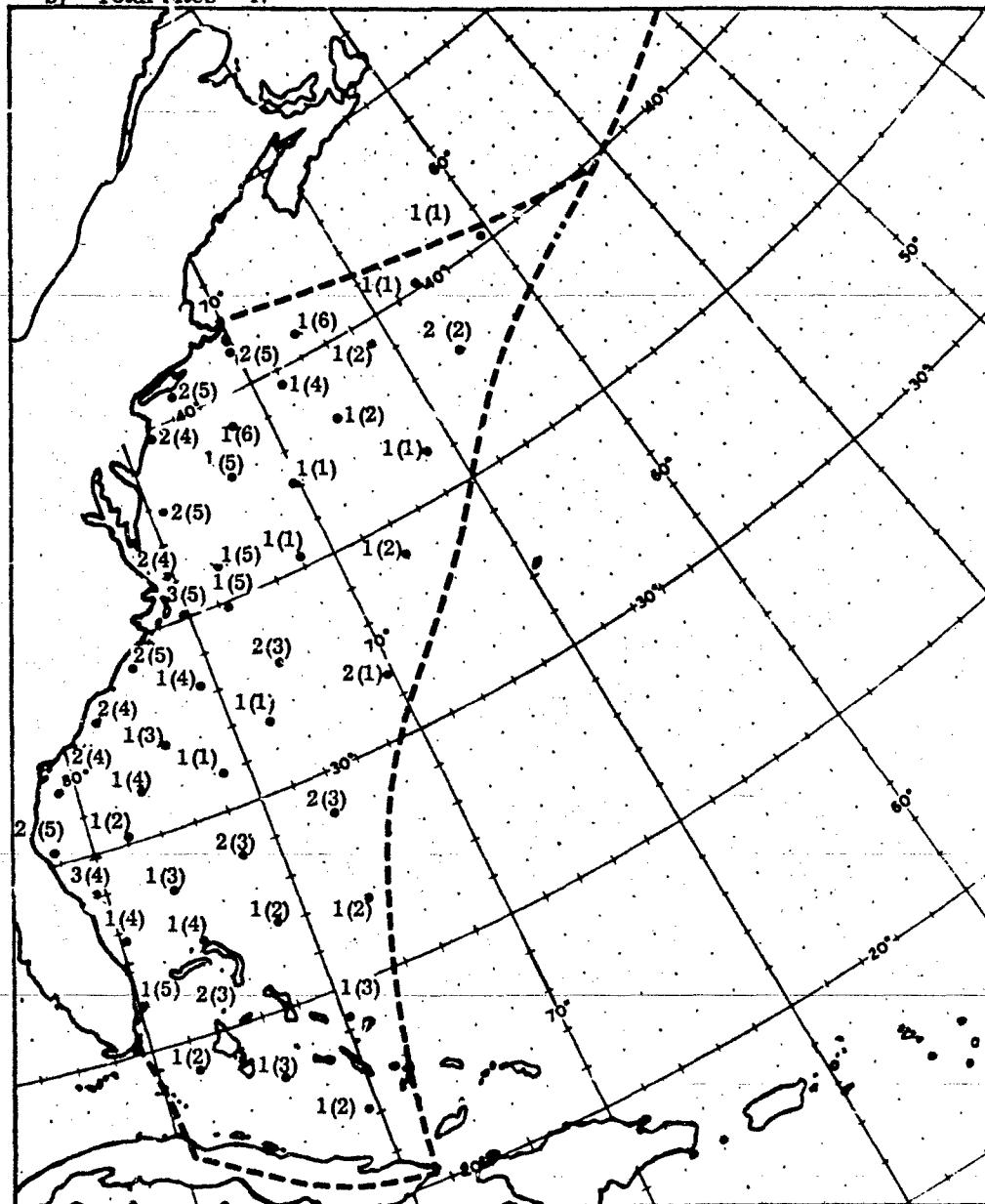


Fig. 6-1B. Distribution in East Coast MDZ of refined operational and research national data requirements at observational sites.

Legend:

a) "8(2)" Equals 8 Operational and 2 Research Requirements
for Observations at Site

b) Total Sites = 54

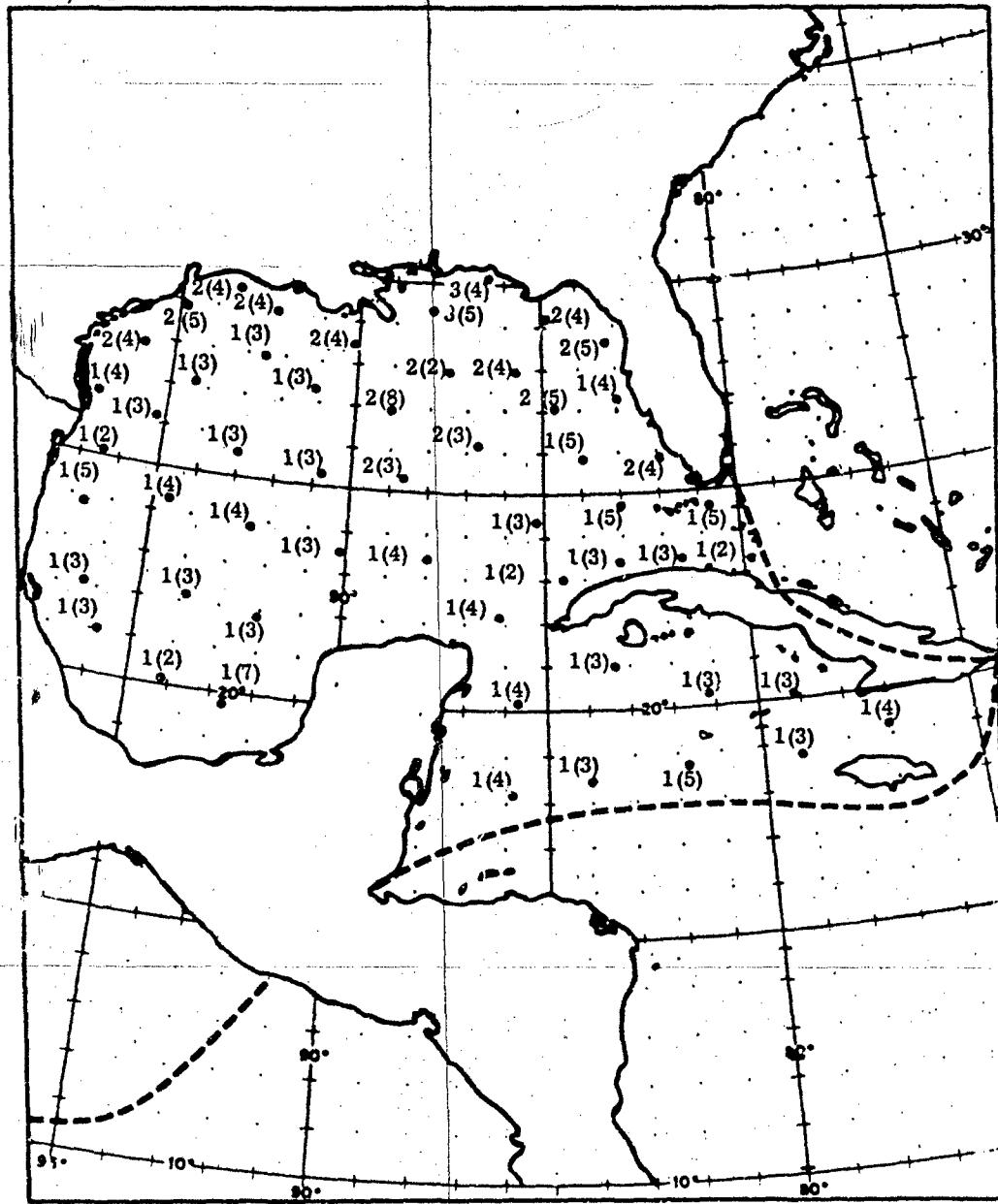


Fig. 6-1C. Distribution in Gulf of Mexico MDZ of refined operational and research national data requirements at observational sites.

Legend:

a) "8(2)" Equals 8 Operational and 2 Research Requirements for Observations at Site

b) Total Sites = 36

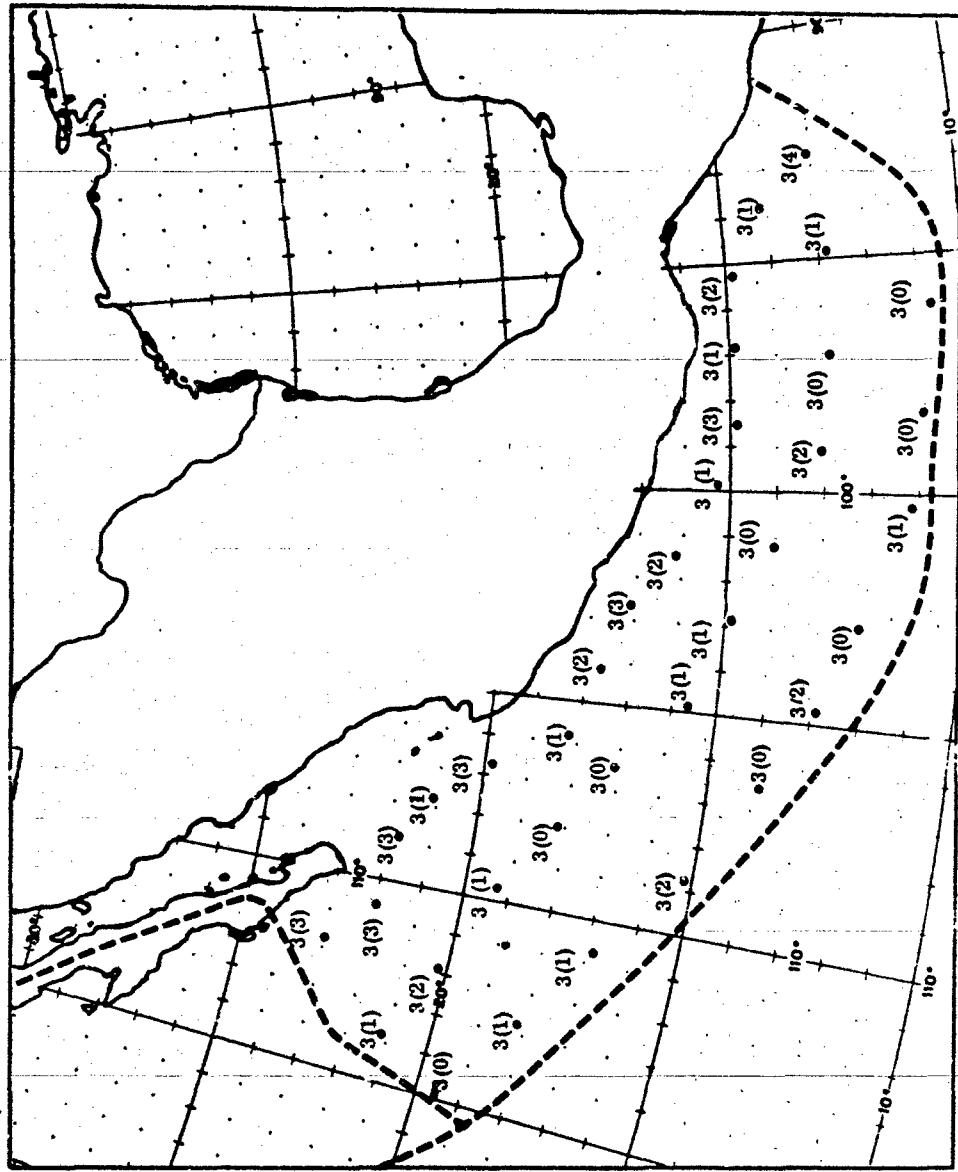


Fig. 6-1D. Distribution in Mexican Coast MDZ of refined operational and research national data requirements at observational sites.

Legend:

- a) "8(2)" Equals 8 Operational and 2 Research Requirements
for Observations at Site
- b) Total Sites = 51

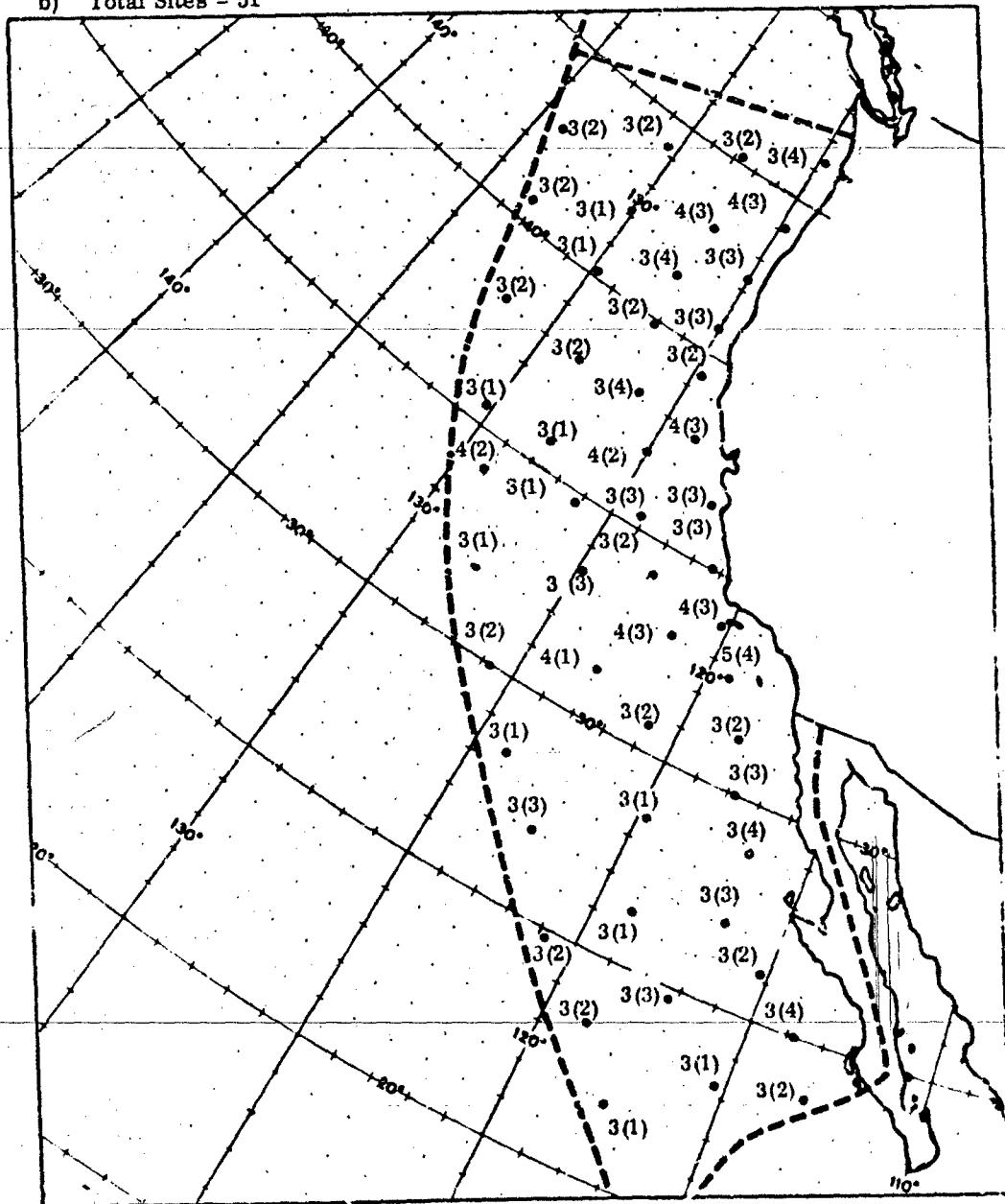


Fig. 6-1E. Distribution in West Coast MEZ of refined operational and research national data requirements at observational sites.

Legend:

a) "8(2)" Equals 8 Operational and 2 Research Requirements
for Observations at Site

b) Total Sites = 48

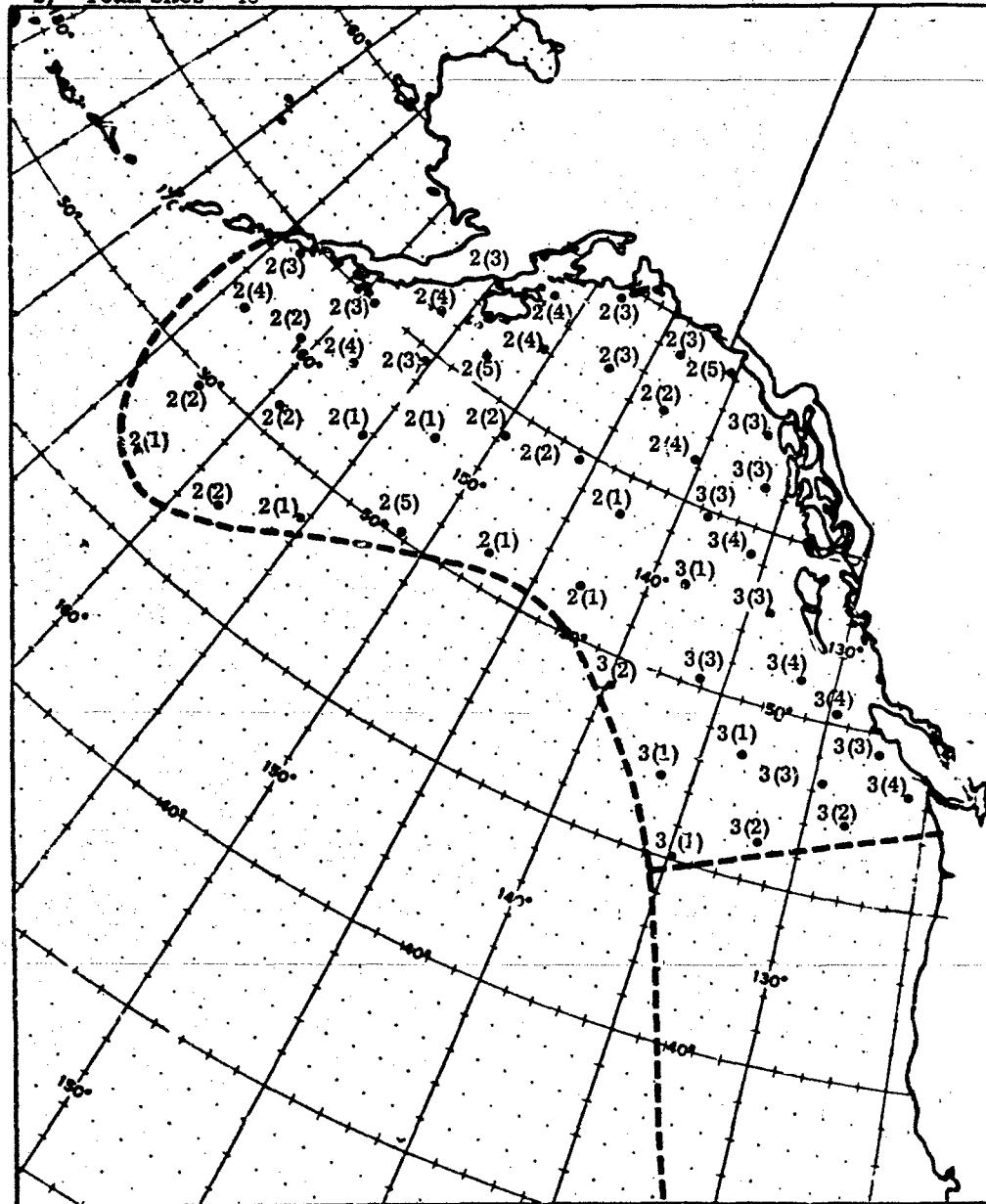


Fig. 6-1F. Distribution in Gulf of Alaska MDZ of refined operational and research national data requirements at observational sites.

Legend:

a) "8(2)" Equals 8 Operational and 2 Research Requirements for Observations at Site

b) Total Sites = 38

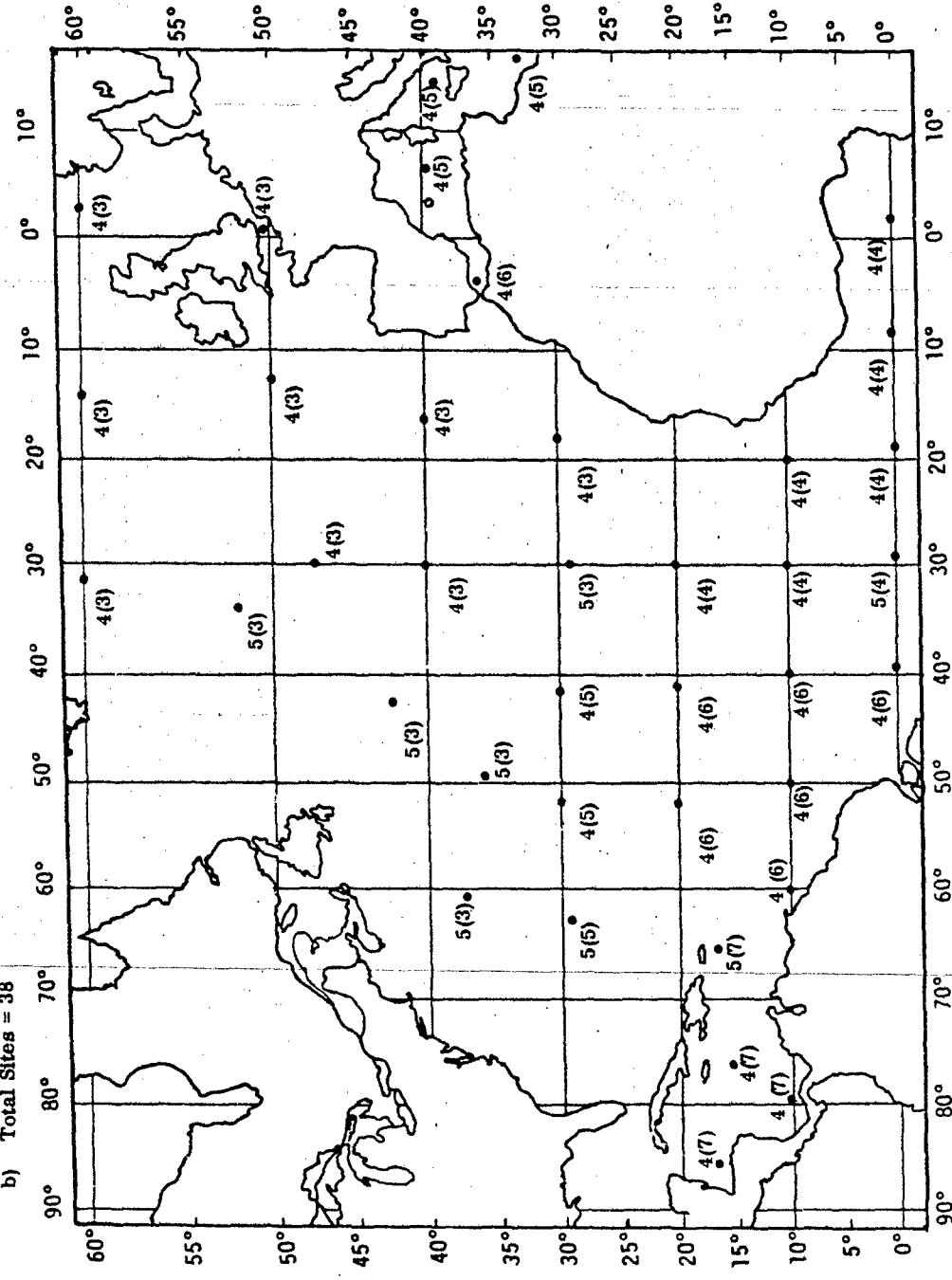


Fig. 6-1G. Distribution in North Atlantic MDZ of refined operational and research national data requirements at observational sites.

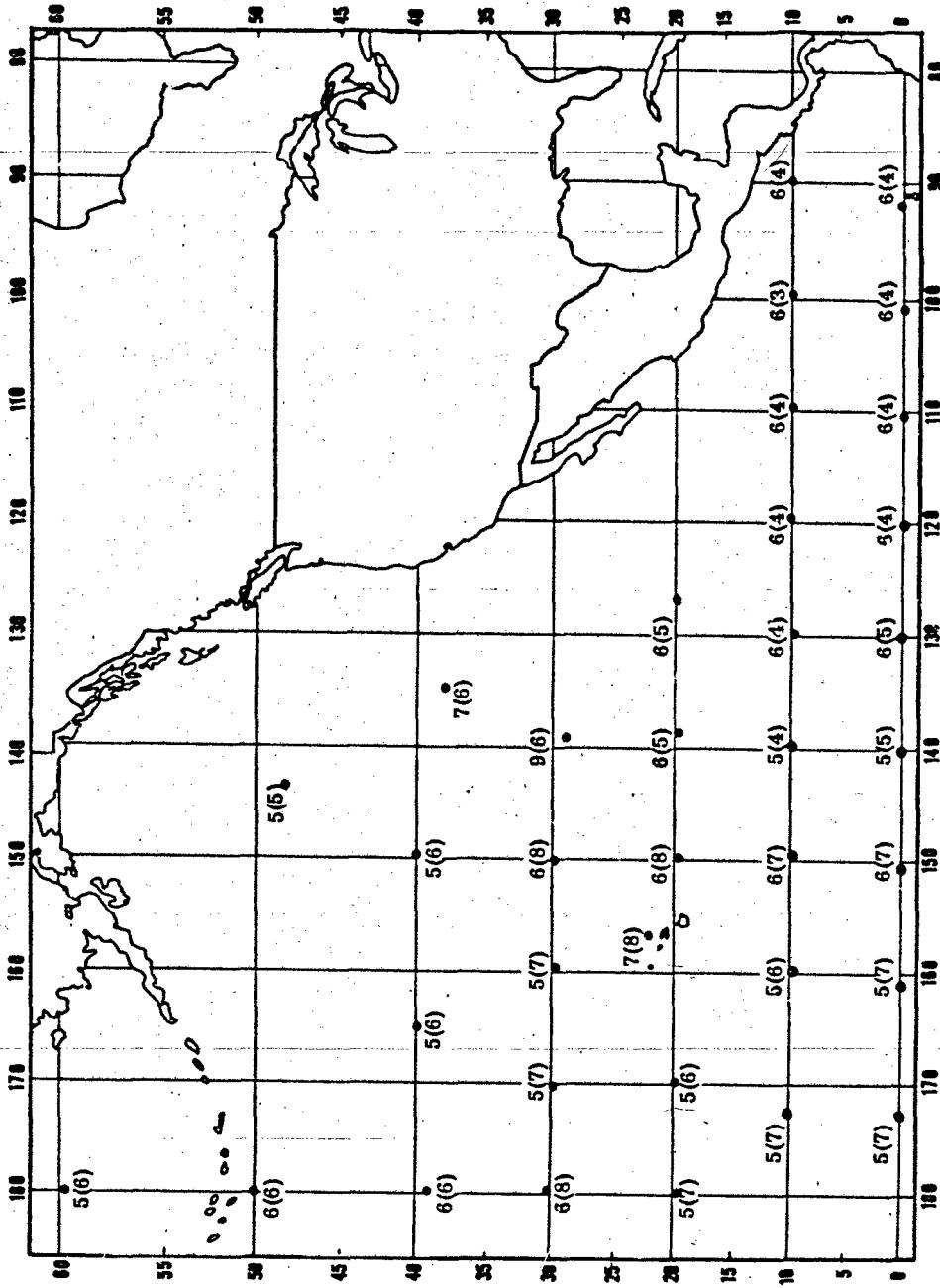
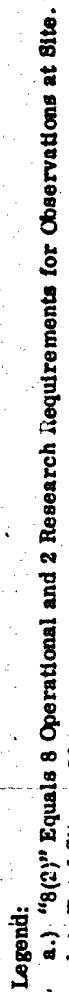


Fig. 6-111. Distribution in North Pacific East MDZ of refined operational and research national data requirements at observational sites.

Legend:

a.) "8(2)" Equals
b.) Total Sites = 3

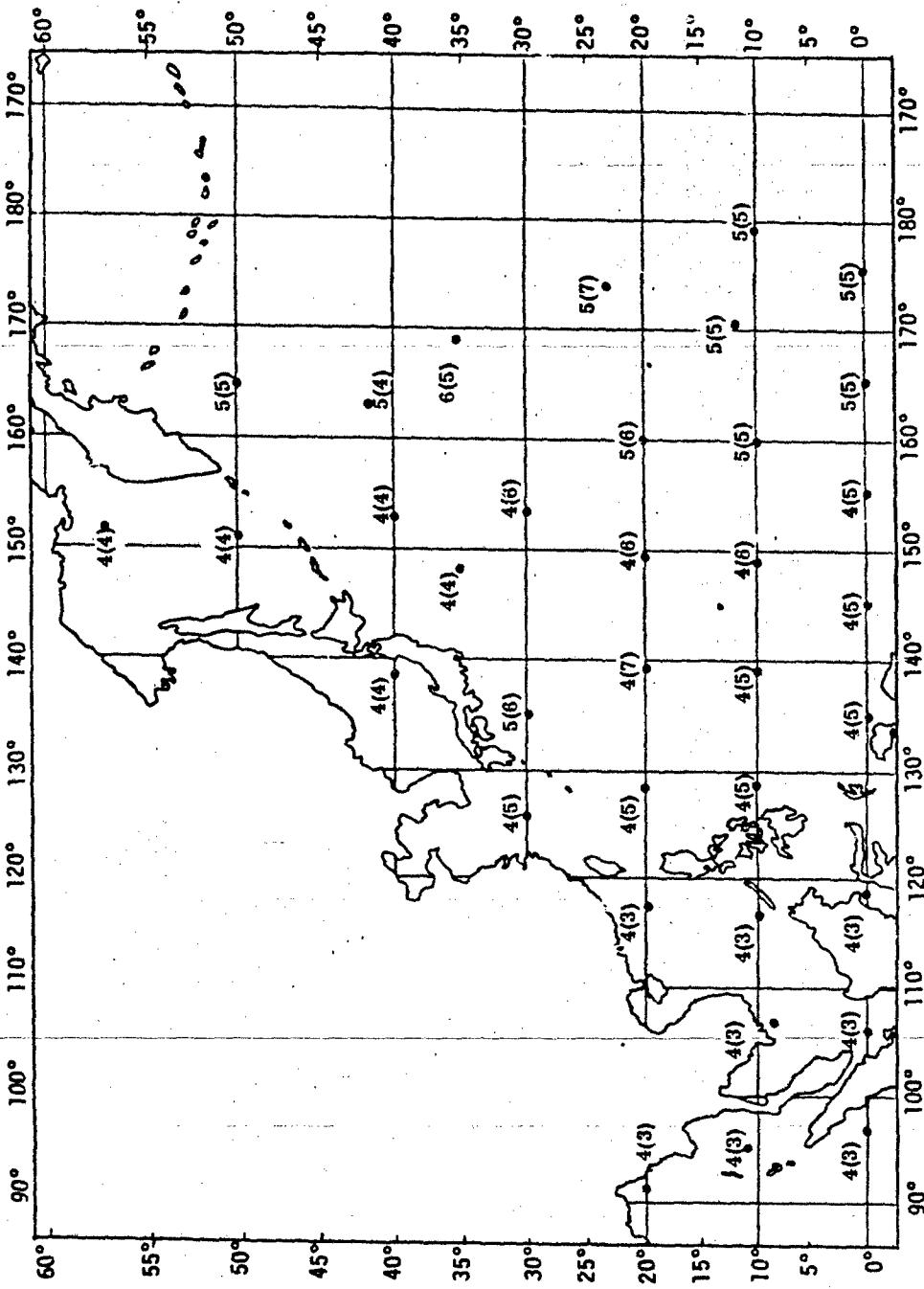


Fig. 6-11. Distribution in North Pacific West MDZ of refined operational and research national data requirements at observational sites.

Legend:

a.) "8(2)" Equals 8 Operational and 2 Research Requirements for Observations at Site.

b.) Total Sites = 33

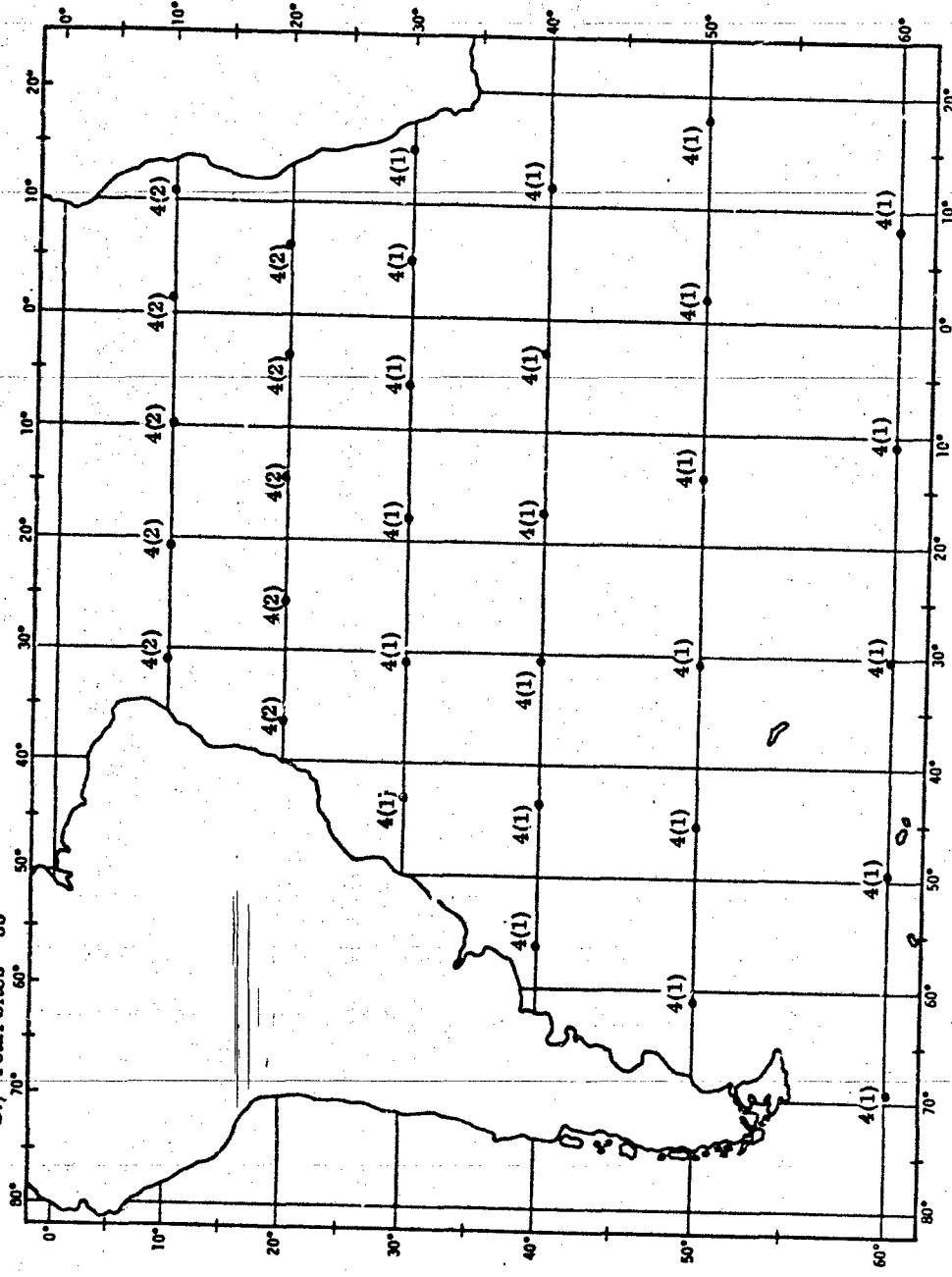


Fig. 6-1J. Distribution in South Atlantic MDZ of refined operational and research national data requirements at observational sites.

Legend:
a) "8(2)" Equals 8 Operational and 2 Research Requirements for Observations at Site
b) Total Sites = 49

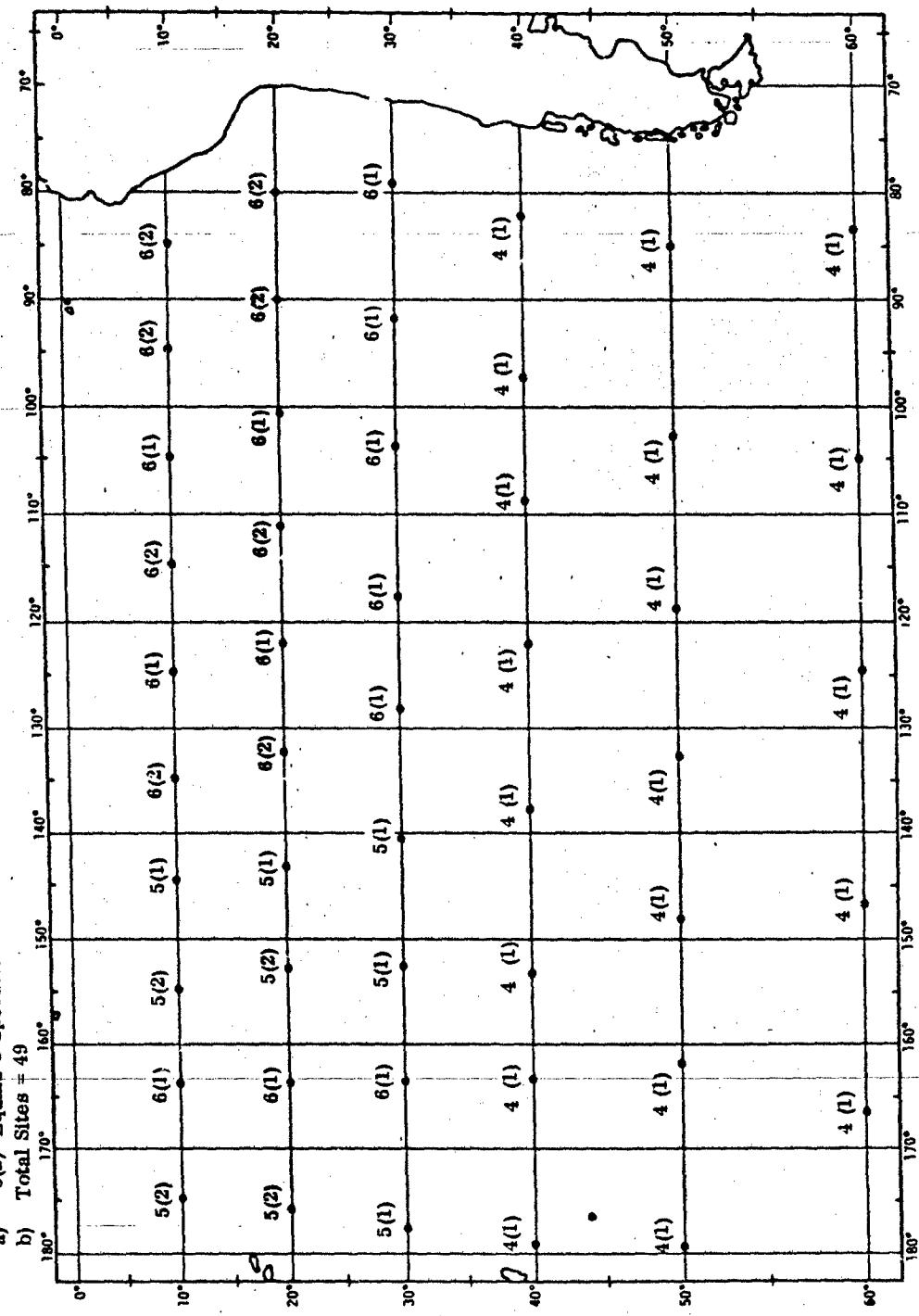


Fig. 6-1K. Distribution in South Pacific East MDZ of refined operational and research national data requirements at observational sites.

Legend:
 a) "8(2)" Equals 8 Operational and 2 Research Requirements for Observations at Site
 b) Total Sites = 35

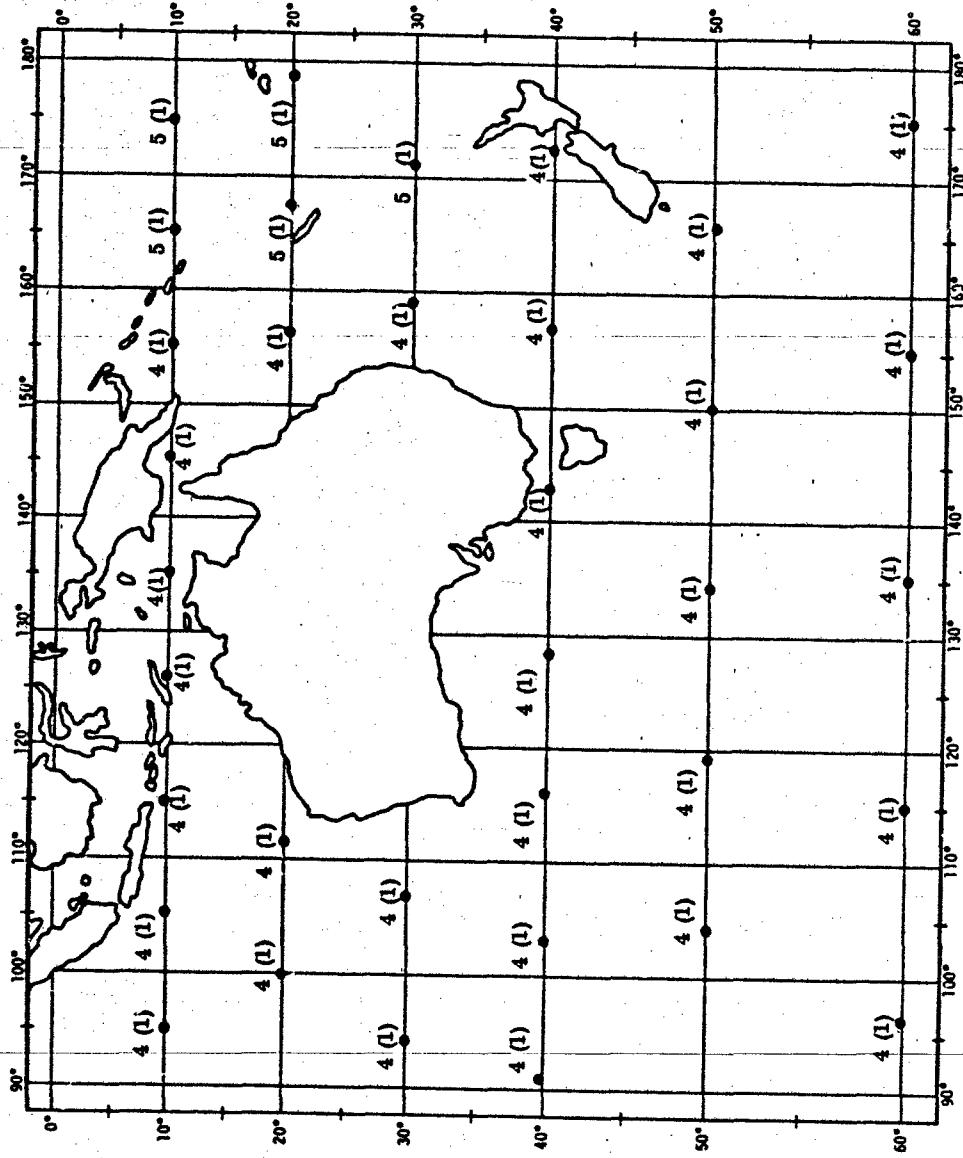


Fig. 6-11L Distribution in South Pacific West MDZ of refined operational and research national data requirements at observational sites.

Legend:

- a) "8(2)" Equals 8 Operational and 2 Research Requirements
for Observations at Site
- b) Total Sites = 35

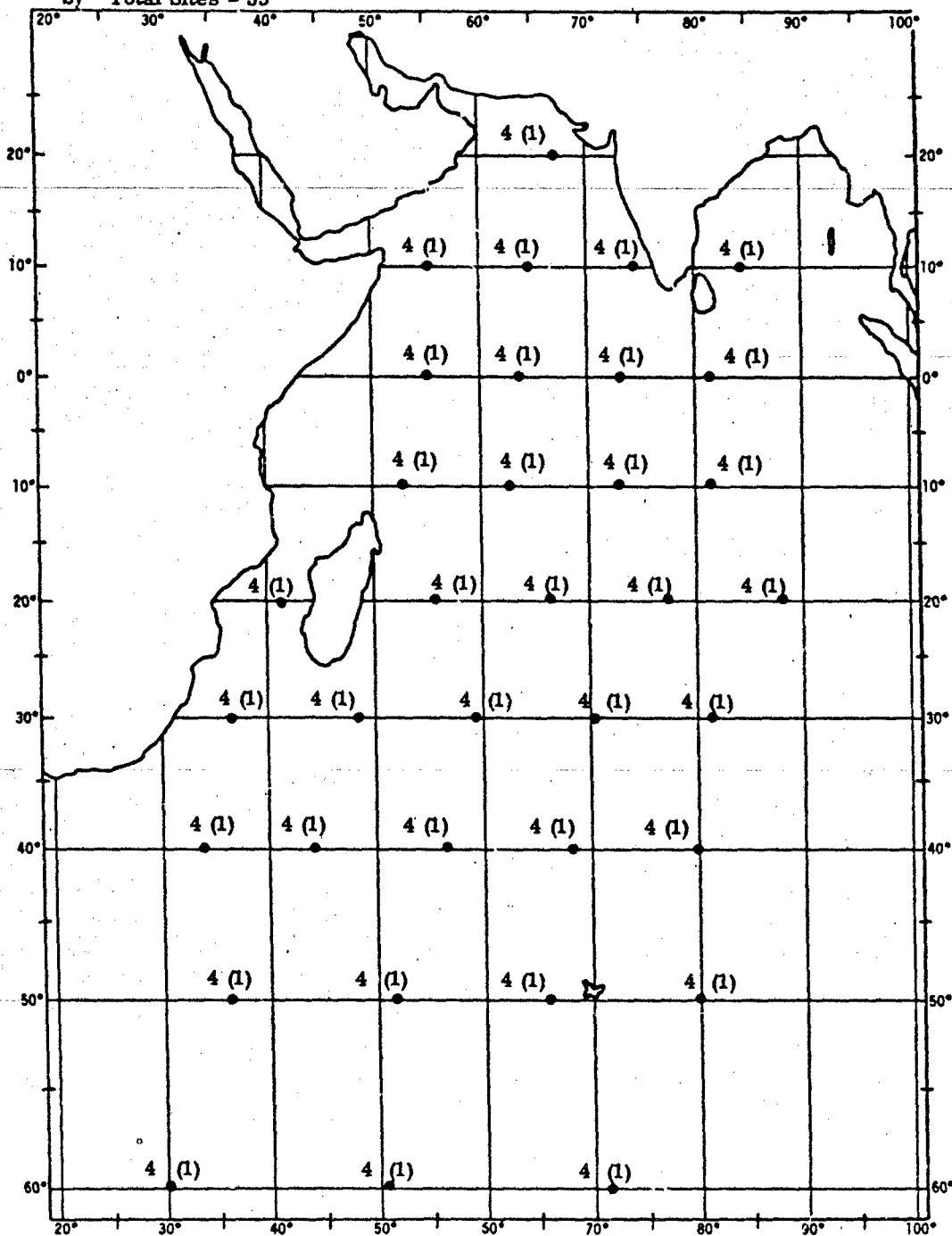


Fig. 6-1M. Distribution in Indian Ocean MDZ of refined operational and research national data requirements at observational sites.

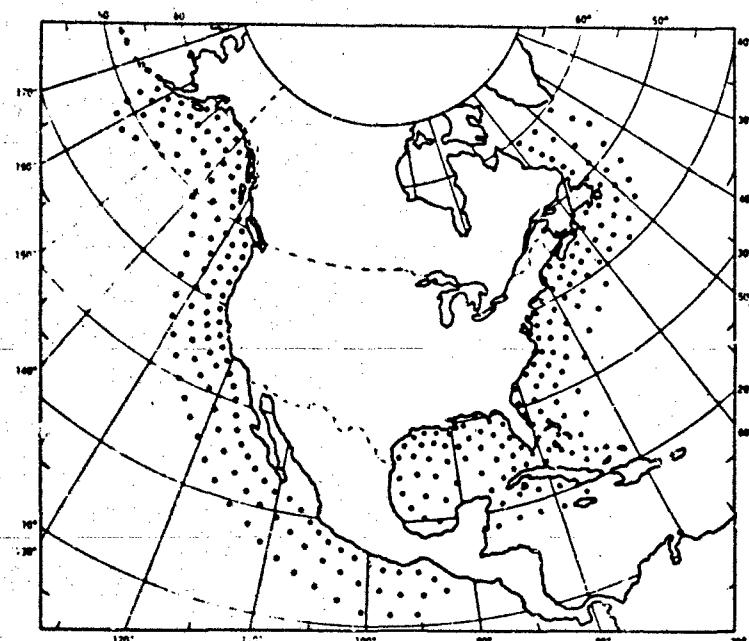


Fig. 6-2. The hypothetical "System" network of observation sites (279 buoys) for the CNA region.

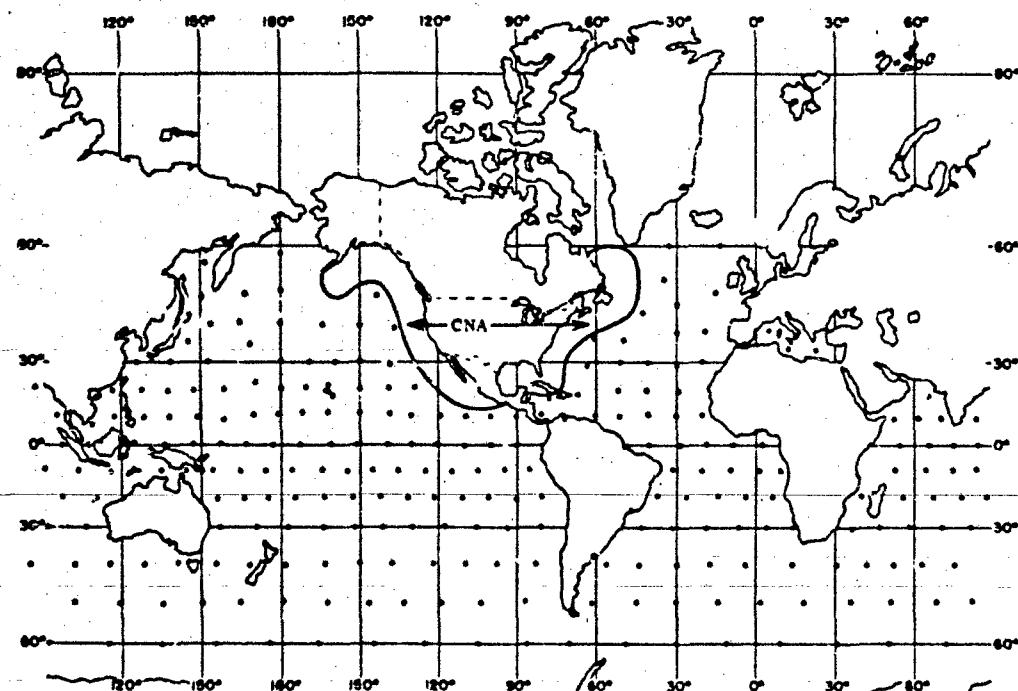


Fig. 6-3. The hypothetical "System" network of observation sites (261 buoys) for the DO region.

7.0 RECOMMENDATIONS FOR FURTHER STUDY

This 1968 effort to refine the statements of data requirements contributed significantly to the understanding of national requirements for marine meteorological and oceanographic data as of mid-1968. It is recognized that data requirements will evolve with time as new operations and data uses evolve. Activities requiring marine environmental data have never had adequate data; therefore, understanding of requirements for data will evolve as more and better data become available, problems come under ever closer scrutiny, and more problems in data use are better understood.

Until now, all stated data requirements discussed in this report have been considered of equal importance. Continuing efforts to establish estimates, by the users, of the relative value or worth of the parameters represent the beginning of a more sophisticated analytical approach in this important area. A constantly evolving approach seeking to establish and improve a firm data requirements base is needed as a foundation for the continuing system planning and development responsibility of the U. S. Coast Guard NDBS DPO. The recommendations listed below are for near-term studies to clarify certain remaining problems in the data requirements area in order to develop sound, adequate data bases for forthcoming NDBS planning and development efforts.

(1) The agencies' efforts to estimate relative values of parameters indicated, as expected, that parameters and observing layers requested by the various agencies are not all of equal importance. It is important, therefore, to extend this work in a quantitative fashion, to achieve an estimation of the system worth of the various data requirements. By relating requirements to costs and benefits, the advisability of various options or trade-offs can be established in cooperation with the relevant government agencies. In particular, this will provide further guidance on such planning and development problems as buoy hull shape and size, maintenance cycle, and sensor development.

(2) To acquire further information about data requirements, pertinent agencies should be solicited for statements of requirements pertaining to data buoy systems, following the general format of the

Tentative Specific Operational Requirements (TSOR). The Naval Air Systems Command has already produced a TSOR for their operational requirements. Undertaking to use the TSORs would encourage other agencies to establish rationales for their mission-operations, data use, and data requirements. Also, agencies would be required to specify deficiencies of the present system and requirements for system enhancement or new efforts to meet marine environmental data requirements. The comparative analysis of information gained from the preparation of TSORs by the agencies would help in the effort to establish the relative urgency of agency data requirements on a national basis.

(3) The national data requirements for the Great Lakes and Near-Shore and Estuaries (GL & NSAE) should be established and analyzed in the same detail as for the DO and CNA regions. Some information has been obtained (e.g., from FWPCA) but the details of the requirements are not yet sufficiently specified for development planning purposes. Each of these regions has unique problems and specialized fine-scale requirements that warrant considerable additional analysis. Required parameters, measurement characteristics, and estimates of relative values and system worth of the parameter and measurement requirements for the GL & NSAE need to be obtained. Properly established data requirements would serve as a valid data base for the systems analysis, cost-effectiveness, interface and trade-off studies required for the GL & NSAE NDBS development and its relationship to the NDBS for DO and CNA.

(4) Meetings should be planned and conducted annually to keep all potential marine environmental data users aware of NDBS development, approach, and progress, and to assure that development is based on the evolving best understanding of requirements. The next meeting should be held in the spring of 1969, for the purpose of attacking certain significant problems that are still unresolved. At each meeting, the status and validity of the whole realm of marine data requirements should be reviewed. These should be meetings with actual working sessions

- involving participation of agency representatives and other marine data users. Invited papers and panel discussions by experts would also be helpful in highlighting significant problem areas. Summary Working Groups might prepare summaries and conclusions drawn from topics discussed. This approach would serve to obtain a consensus of opinion from the marine data users of the successes and deficiencies of data requirements analyses and assessments and the applicability of NDBS development accomplishments and plans. Close and continuing involvement of NDBS developers with organizations having requirements and uses for marine environmental data is considered necessary.

8.0 REFERENCES

1. Aubert, E.J., 1967: National Requirements for Marine Meteorological and Oceanographic Data. TRC Report 7485-253, Final Report, Volume 1, Part 1, under Contract TCG-16790-A with the U.S. Coast Guard.
2. Walden, R.G., and E.J. Aubert, 1967: Buoy and Buoy Components Data Compilation and Analysis. TRC Report 7485-256, Final Report, Volume 1, Part 2, under Contract TCG-16790-A with the U.S. Coast Guard.
3. Jenkins, C.F., E.J. Aubert, W.R.B. Caruth, L.H. Clem, and R.G. Walden (AGA), 1967: A Cost Effectiveness Evaluation of Buoy and Non-Buoy Systems to Meet the National Requirements for Marine Data. TRC Report 7485-274, Final Report, Volume 1, Part 3, under Contract TCG-16790-A with the U.S. Coast Guard.
4. Northrop, G.M., W.R.B. Caruth, E.L. Davis, L.J. Reed, and J.A. Russo, Jr., 1967: Cost-Benefits for a National Data Buoy System: An Essay. TRC Report 7485-280, Final Report, Volume 2, under Contract TCG-16790-A with the U.S. Coast Guard.
5. Aubert, E.J., A.W. Bostick, L.H. Clem, and R.G. Walden (AGA), 1967: Technical Development Plans for the National Data Buoy System. TRC Report 7485-270, Final Report, Volume 3, under Contract TCG-16790-A with the U.S. Coast Guard.
6. Aubert, E.J., L.H. Clem, C.F. Jenkins, and G.M. Northrop, 1968: A Summary of the Study of the Feasibility of National Data Buoy Systems. TRC Report 7485-286, under Contract TCG-16790-A with the U.S. Coast Guard.

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20. ABSTRACT <p><u>Volume I</u> - This report documents the 1968 refinement of requirements for marine meteorological and oceanographic data—initially compiled during the 1967 Study of the Feasibility of National Data Buoy Systems—and shows the applicability of certain postulated National Data Buoy Systems sensing characteristics to a subset of the refined data requirements. Included in the refined requirements to support national operational and research activities are physical, biological, chemical, geological and radiological parameters which are to be measured throughout the world's oceans from the ocean bottom to 100,000 feet in the atmosphere. The data requirements are projected from the present to as far as 15 years into the future.</p> <p>The study presents a subset of 20 parameters suggested as being representative of the basic sensing characteristics of a future deep ocean or coastal North American National Data Buoy Systems. Estimates of relative values of parameters and observing layers are also included in this study as part of the documentation of the ongoing effort to provide a base for the assessment of hypothetical technically feasible sensing characteristics within the 5 year state-of-the-art.</p> <p><u>Volume II</u> - This report contains five supporting Appendixes for Volume I.</p>			

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